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Shelton, IV

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(54) **STAPLE CARTRIDGES FOR FORMING STAPLES HAVING DIFFERING FORMED STAPLE HEIGHTS**

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See application file for complete search history.

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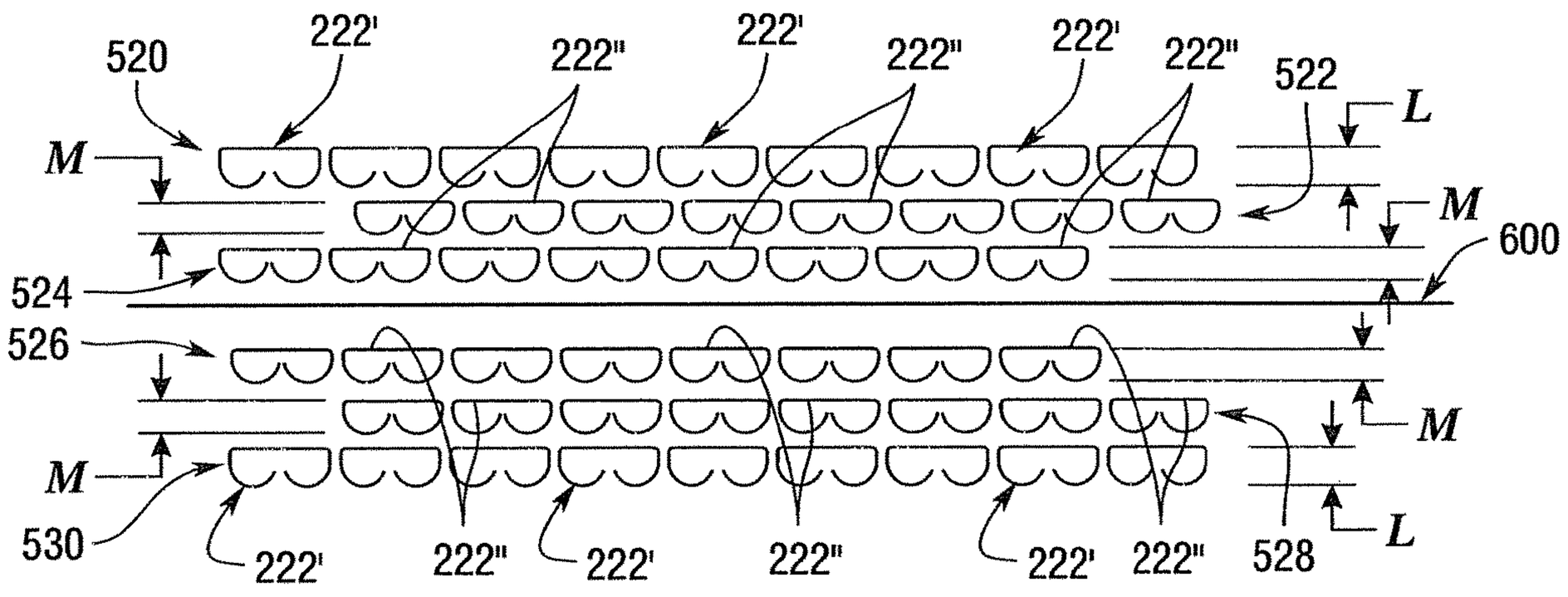
(57) **ABSTRACT**

A staple cartridge for use with a stapling device that has an actuator that is selectively actuatable in an axial direction and an anvil portion that is selectively movable between open and closed positions is disclosed. Various embodiments of the present invention include a cartridge body that movably supports first and second staple drivers. The staple drivers each support a staple thereon and serve to drive the staples into forming contact with the anvil upon actuation by the actuator. The various embodiments of the present invention enable the final formed heights of the staples to be varied without the need to use different sizes of staples.

20 Claims, 27 Drawing Sheets



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continuation of application No. 15/073,168, filed on Mar. 17, 2016, now Pat. No. 10,245,032, which is a continuation of application No. 13/795,122, filed on Mar. 12, 2013, now Pat. No. 9,326,768, which is a continuation of application No. 12/695,359, filed on Jan. 28, 2010, now Pat. No. 8,464,923, which is a continuation of application No. 11/216,562, filed on Aug. 31, 2005, now Pat. No. 7,669,746.

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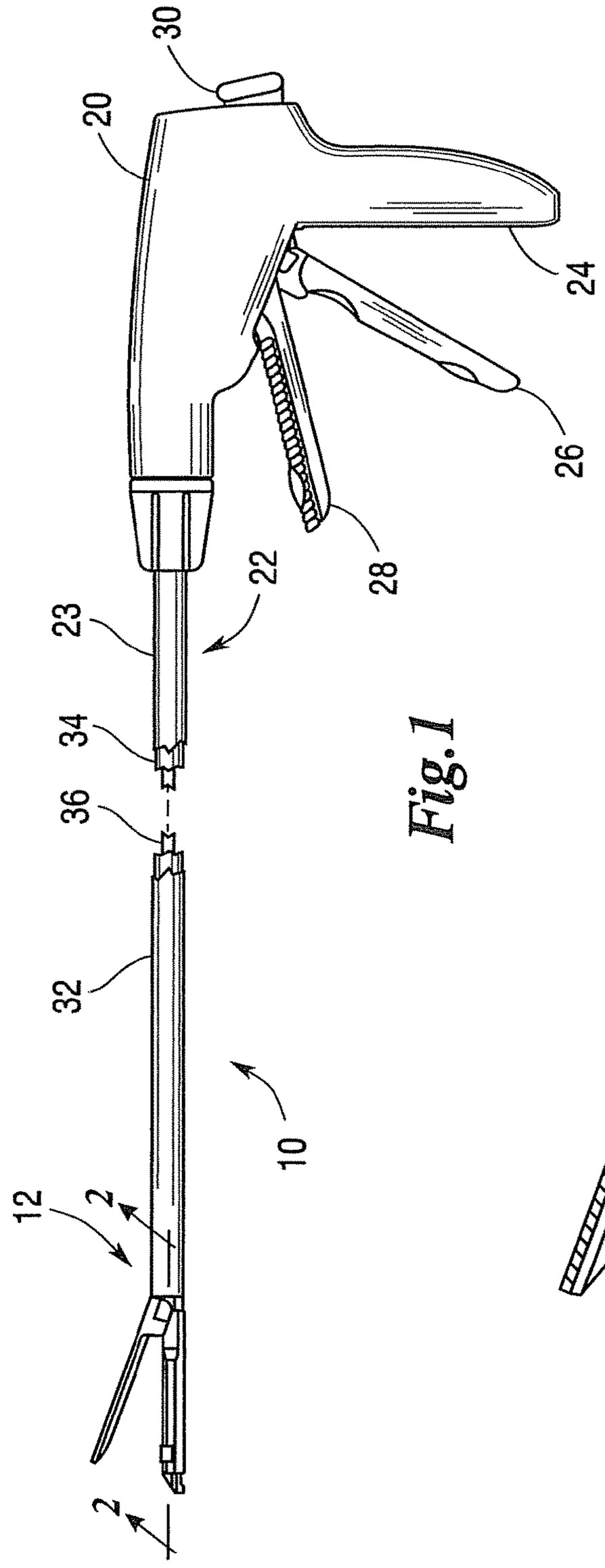
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Fig. 1

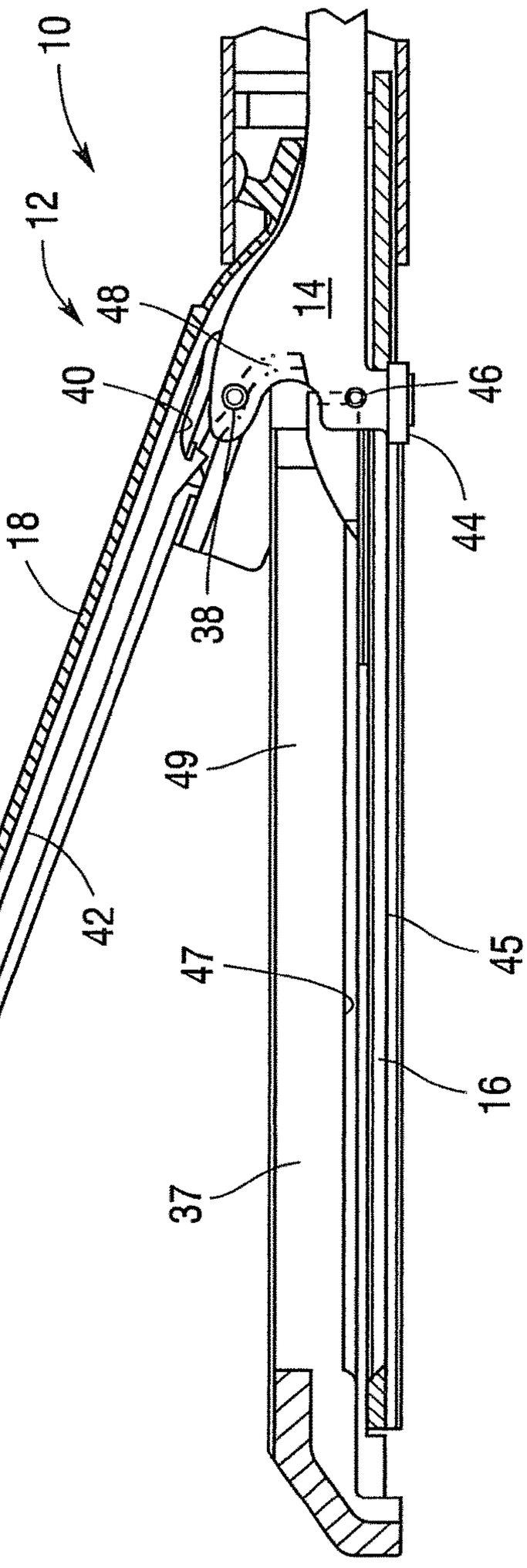
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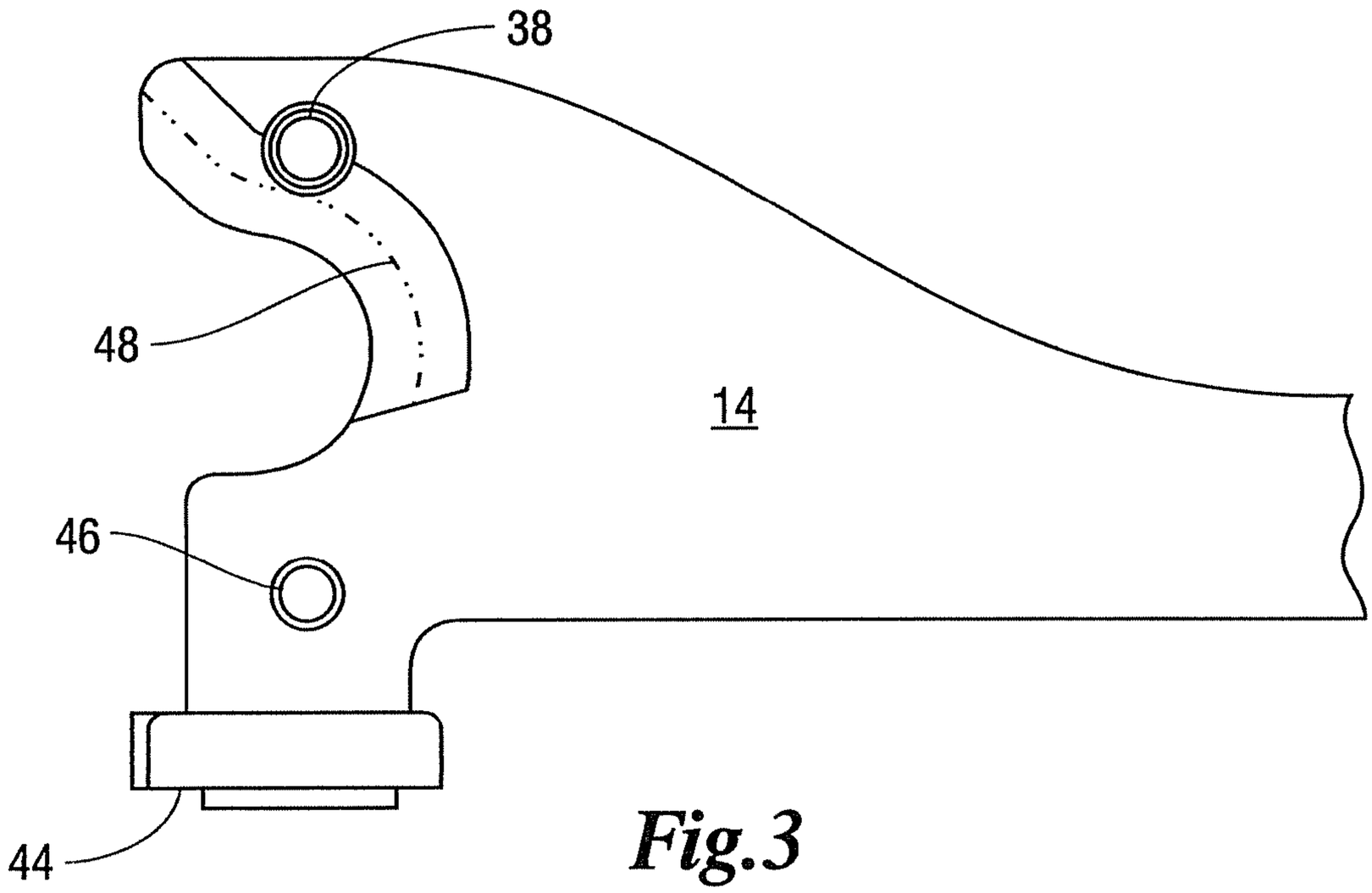
Fig. 2



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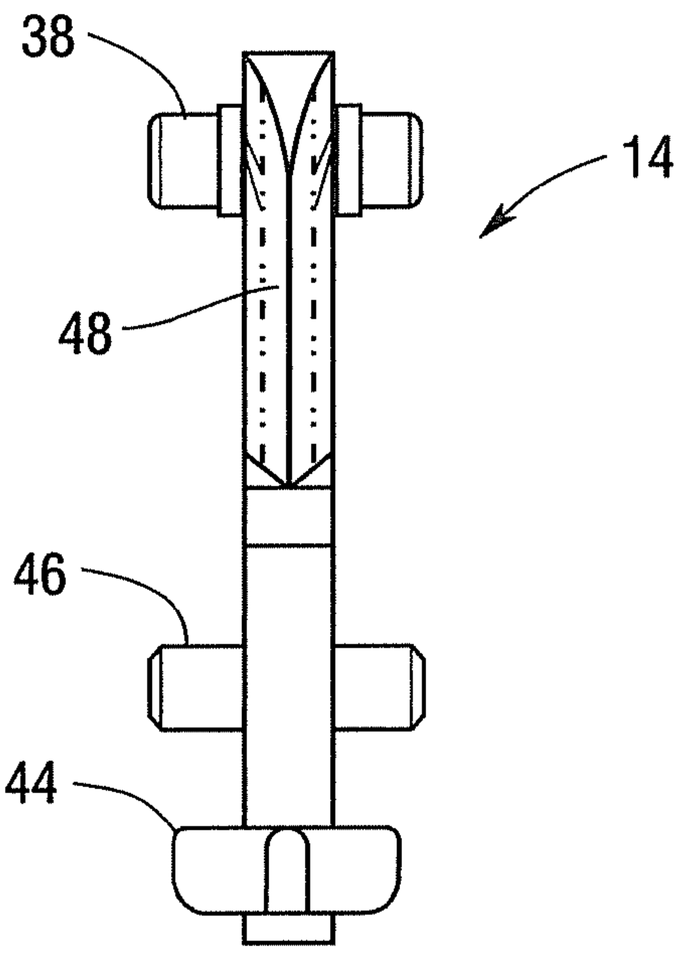

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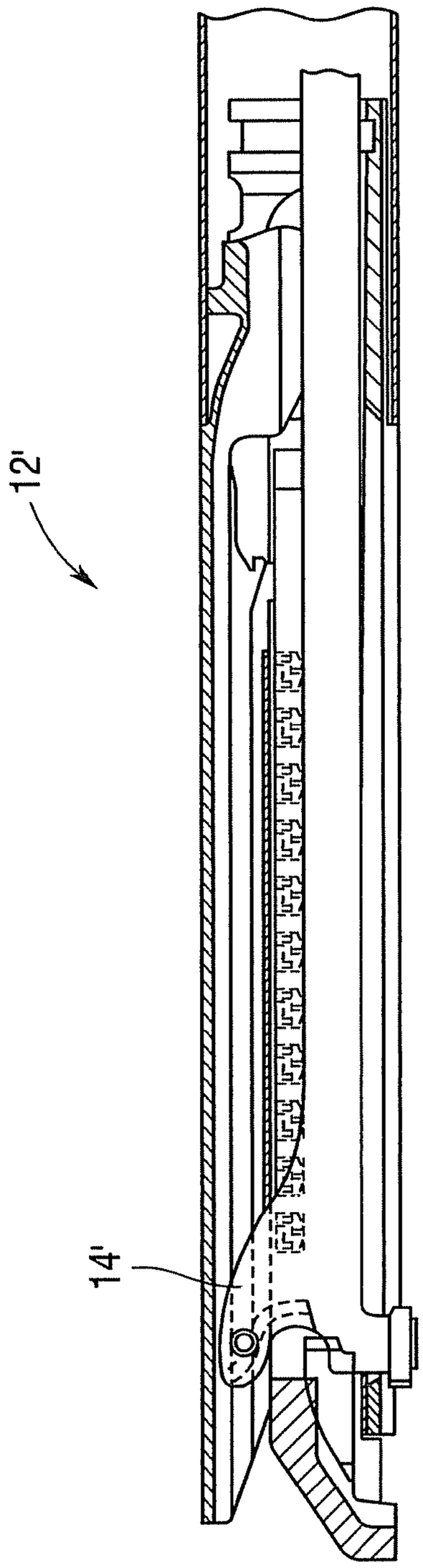

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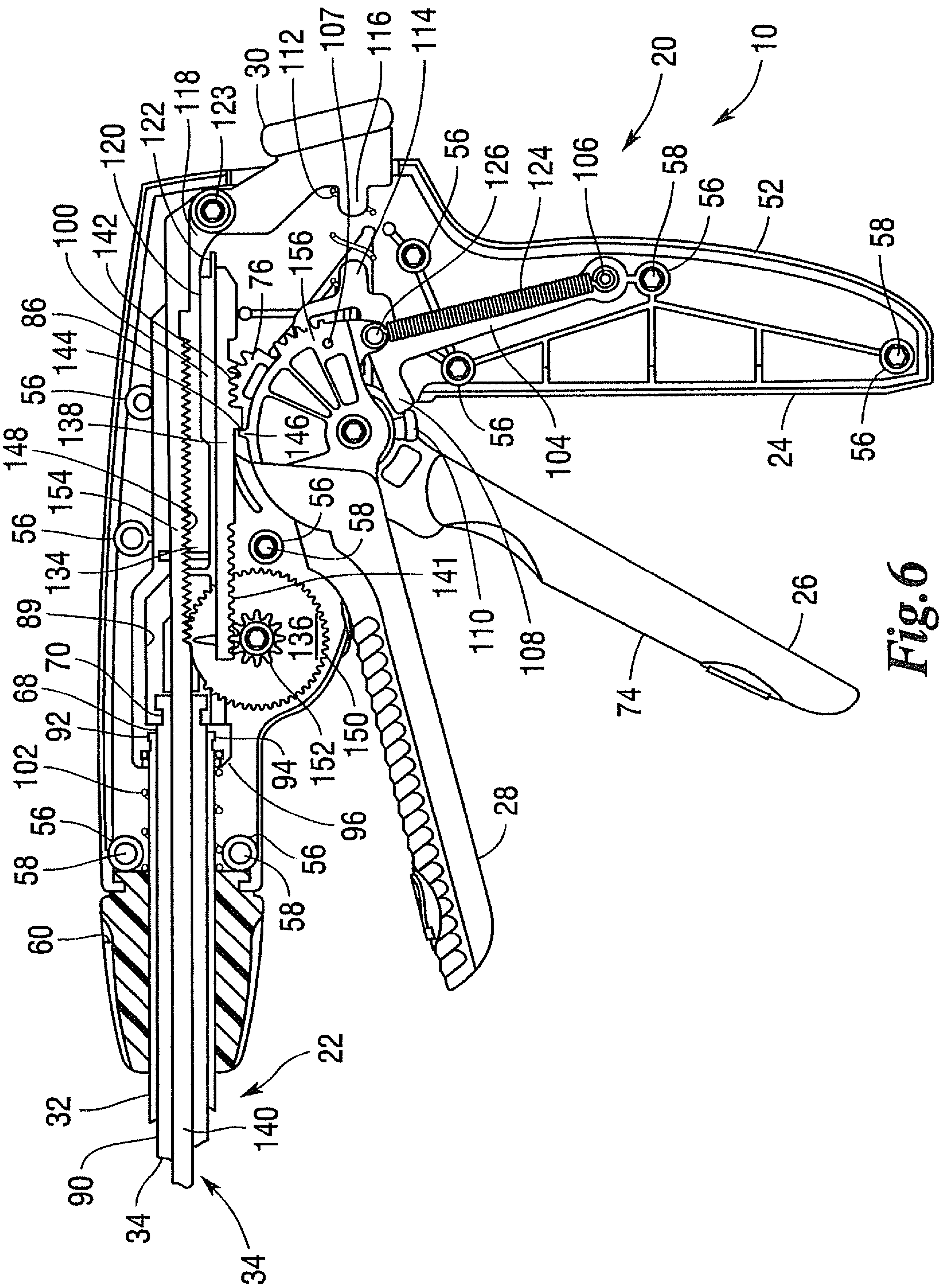
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Fig.6

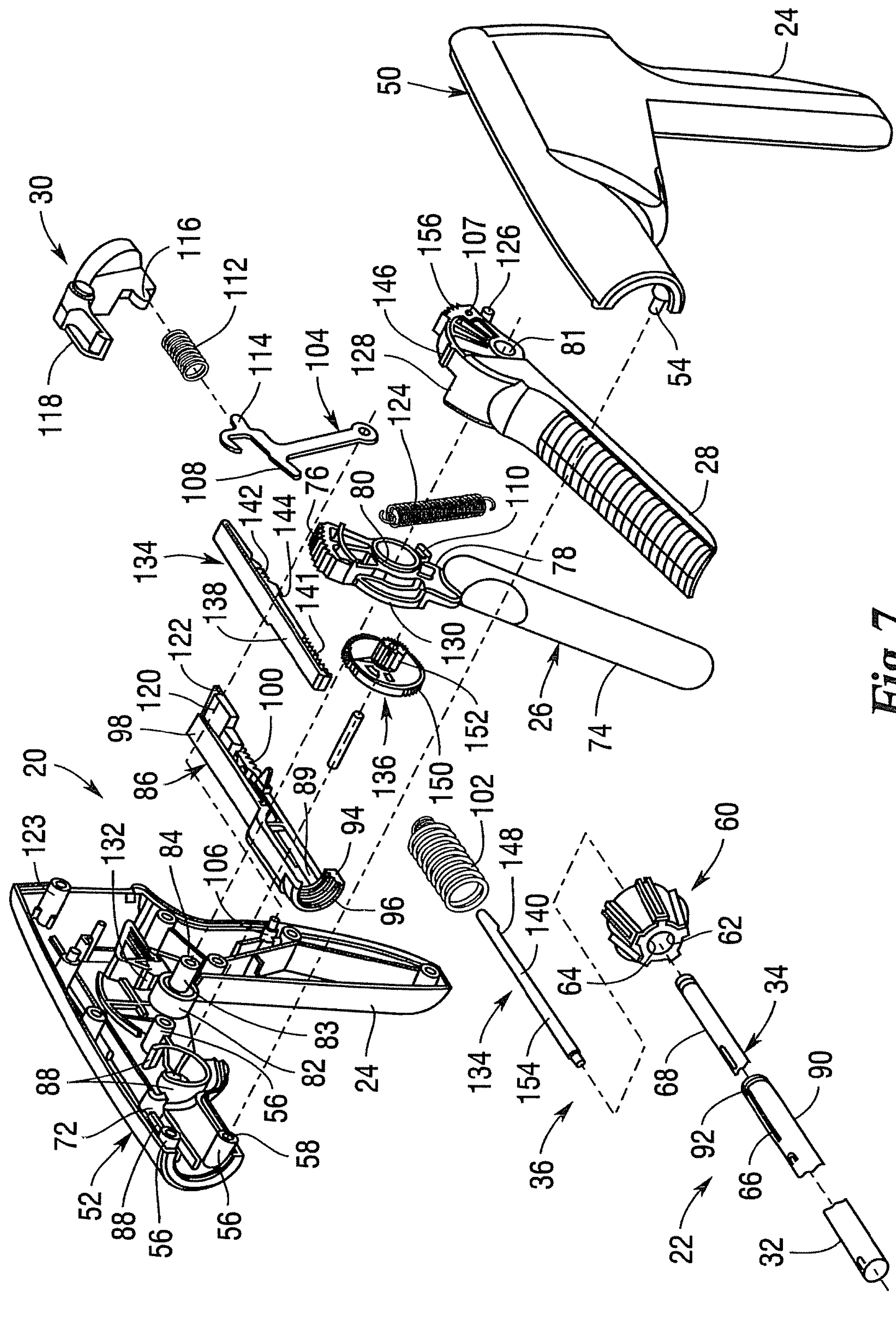

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Fig. 7

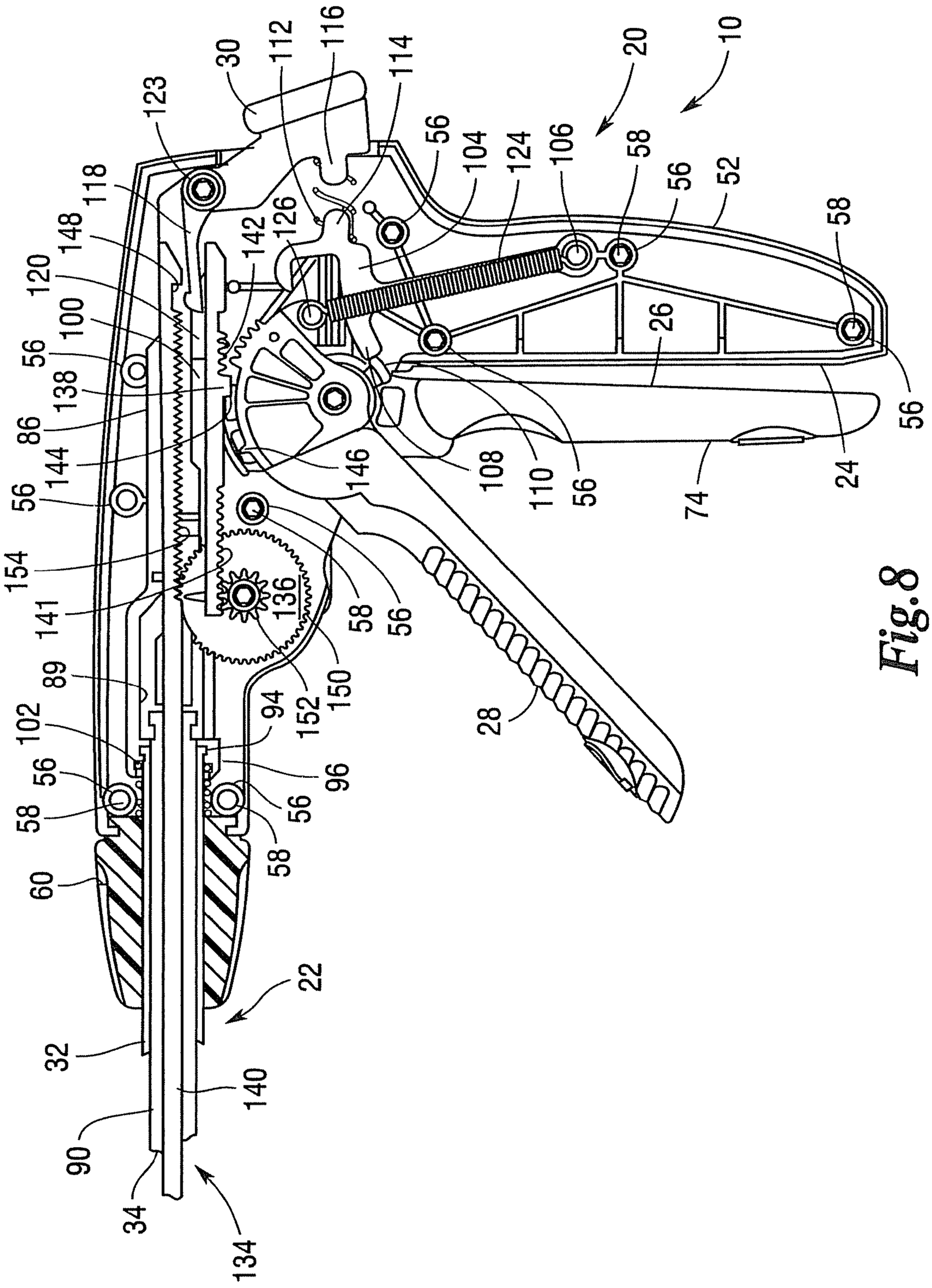
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Fig. 8

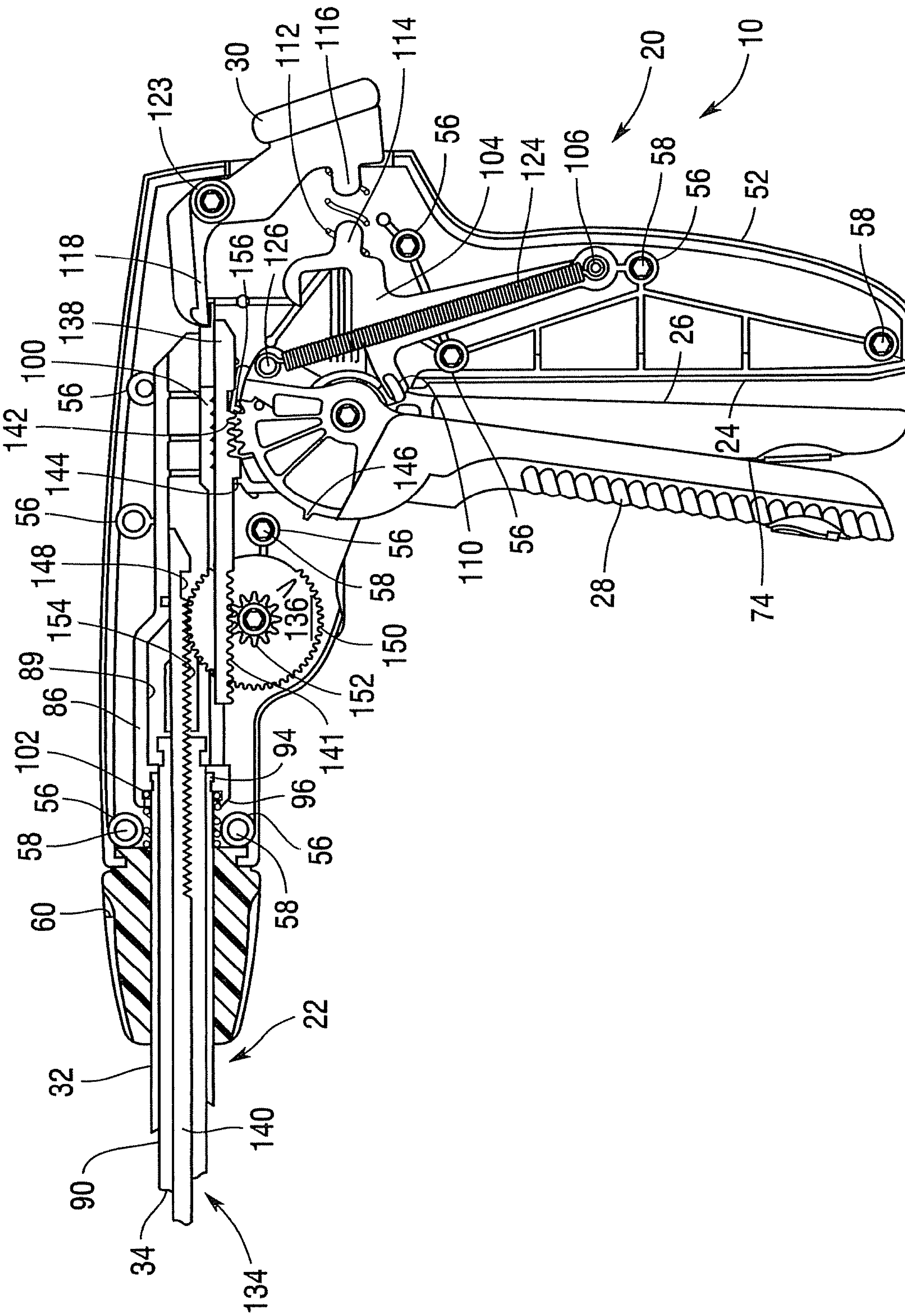
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Fig. 9

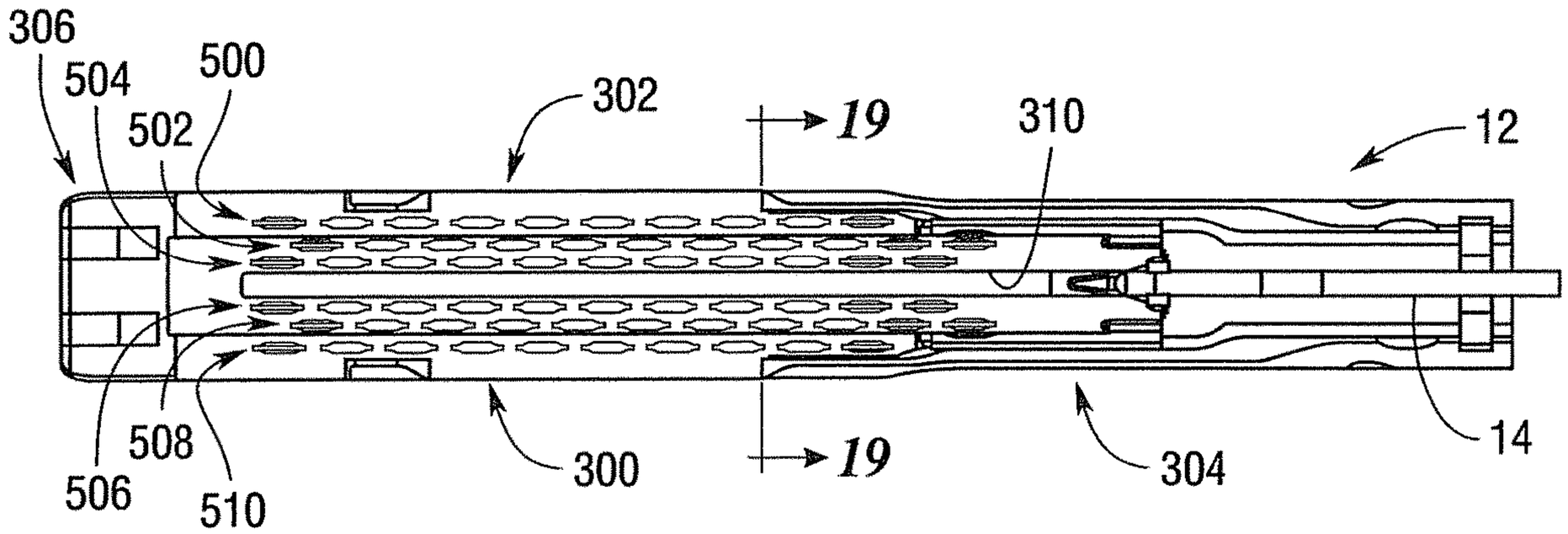
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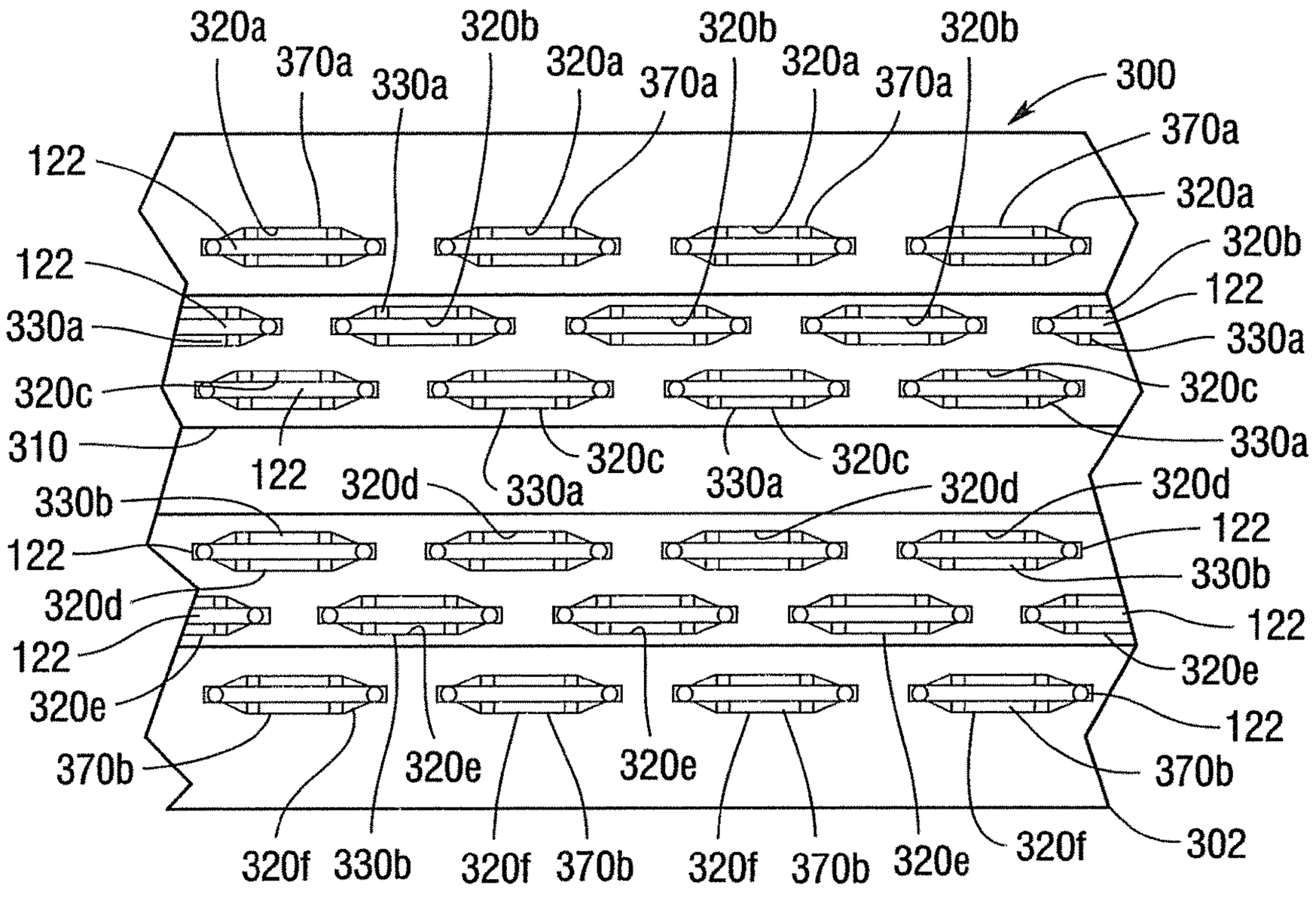
Fig.10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320e
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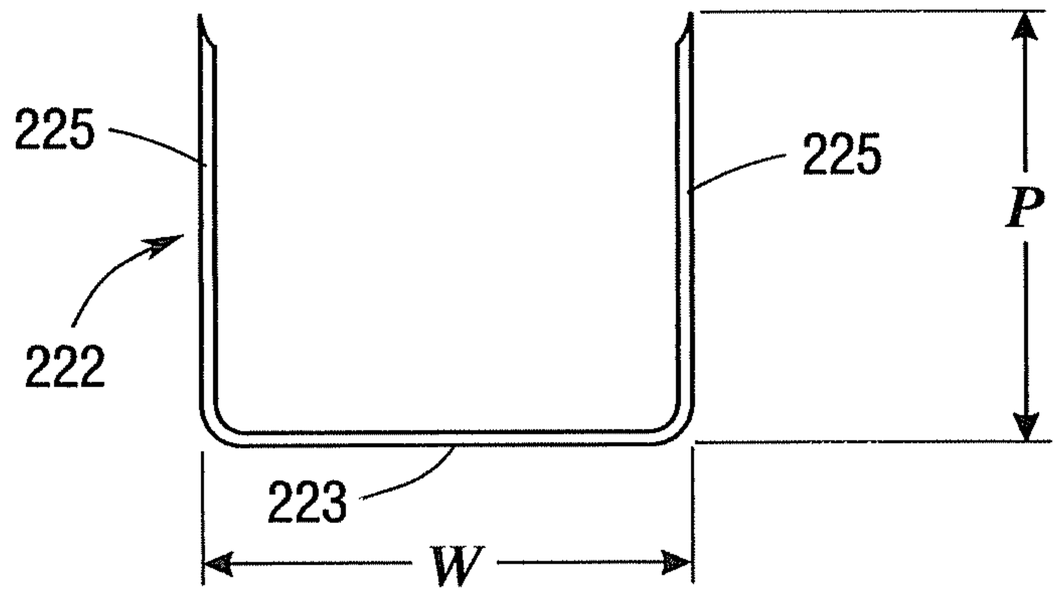
Fig.11

Fig.12



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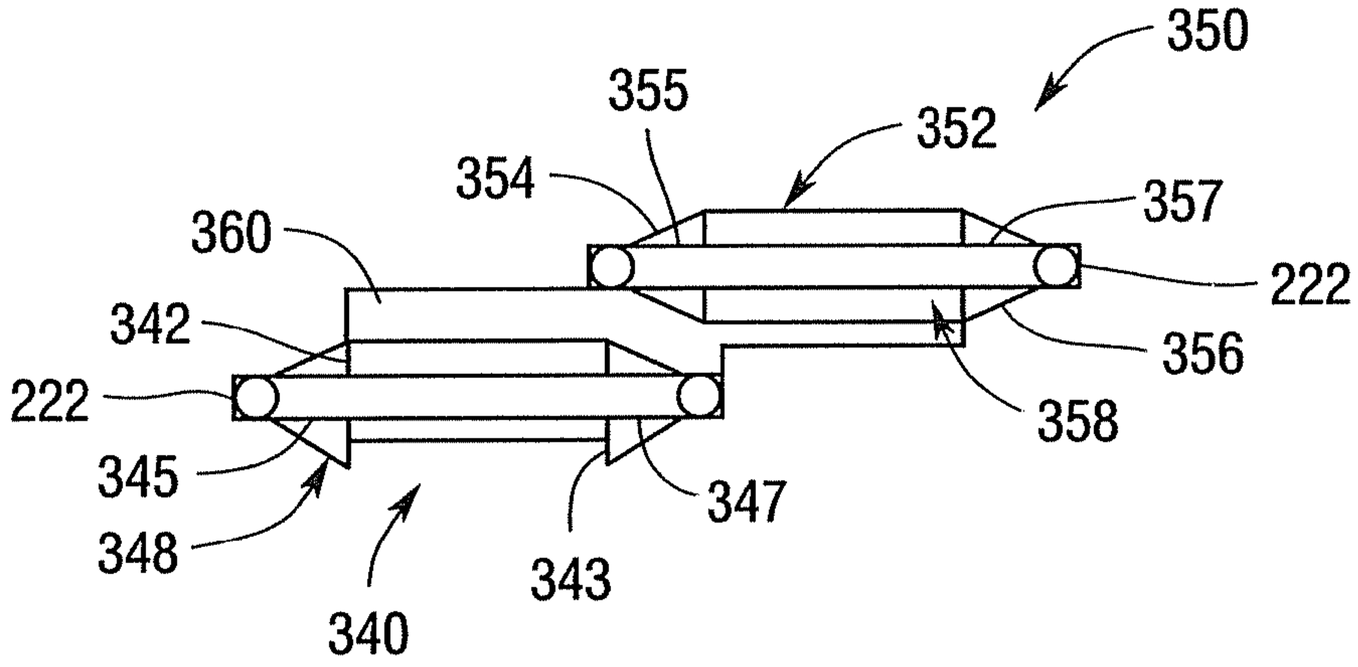
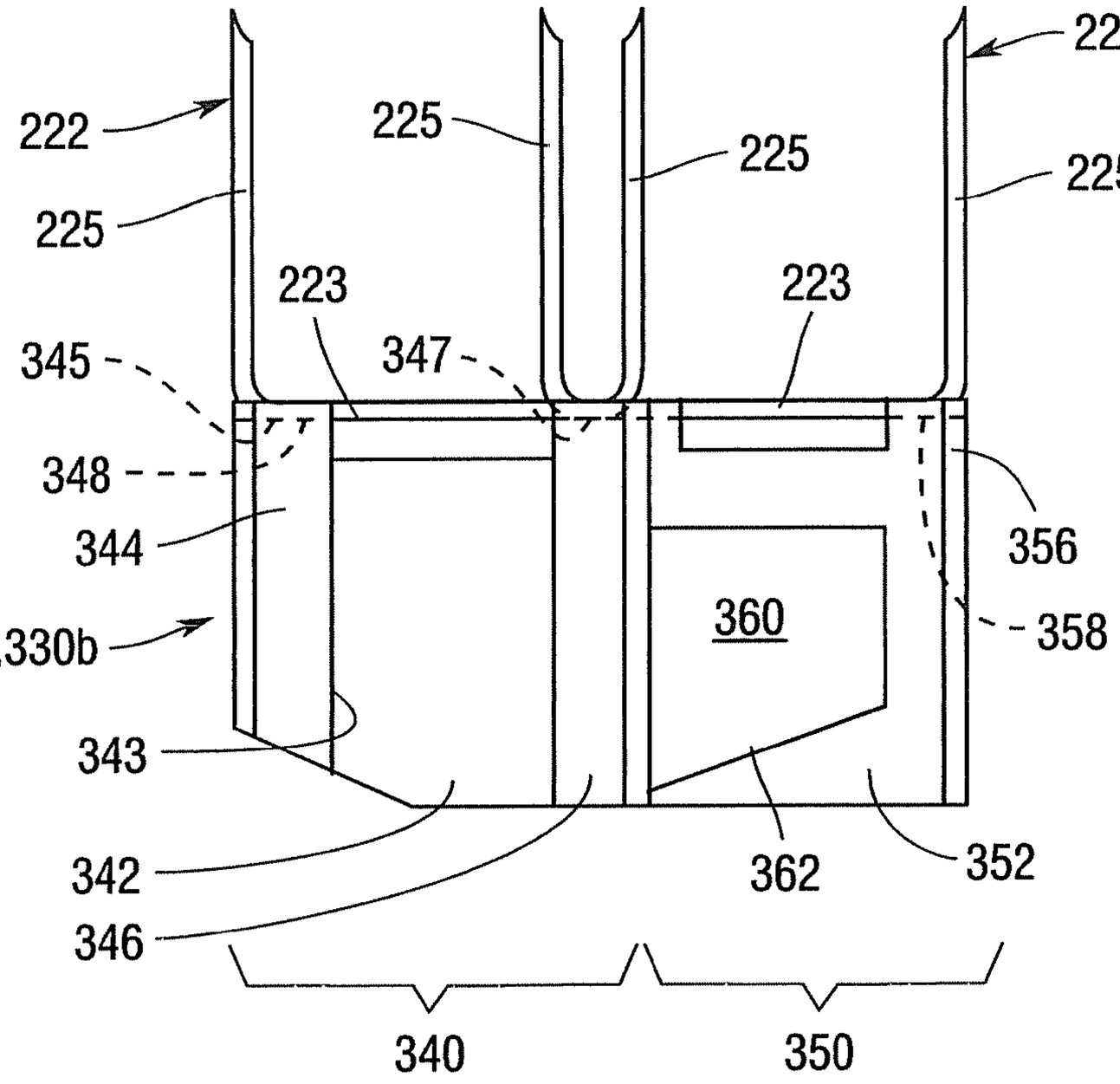
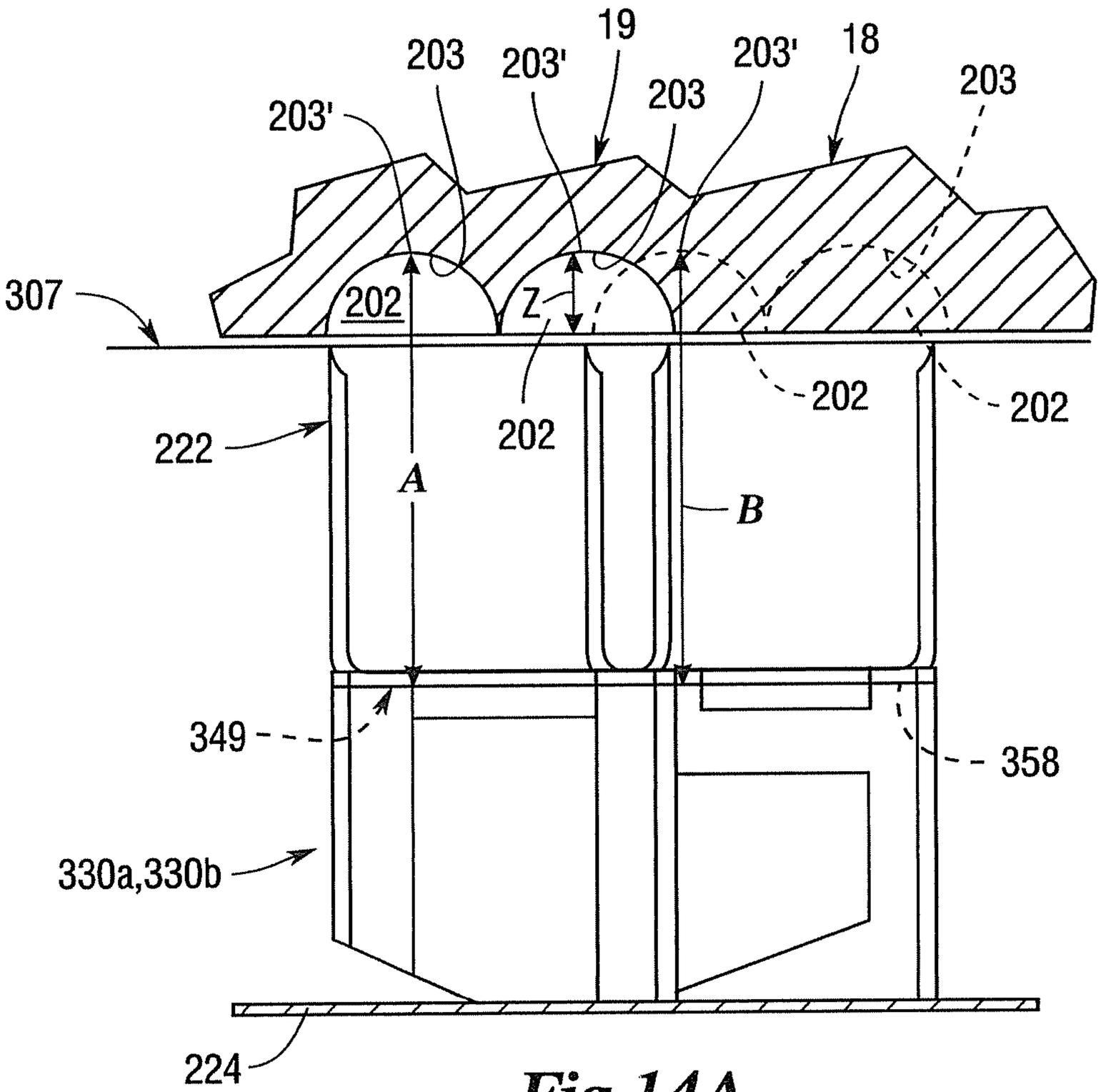


Fig.13

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330a,330b
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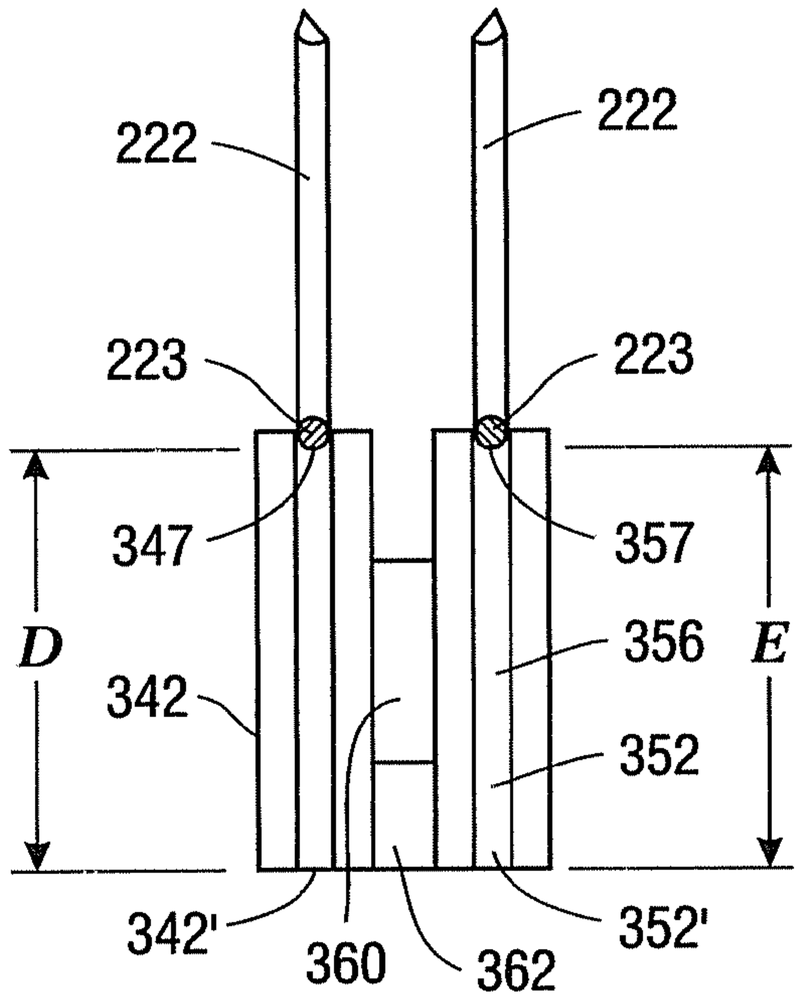
Fig.14A



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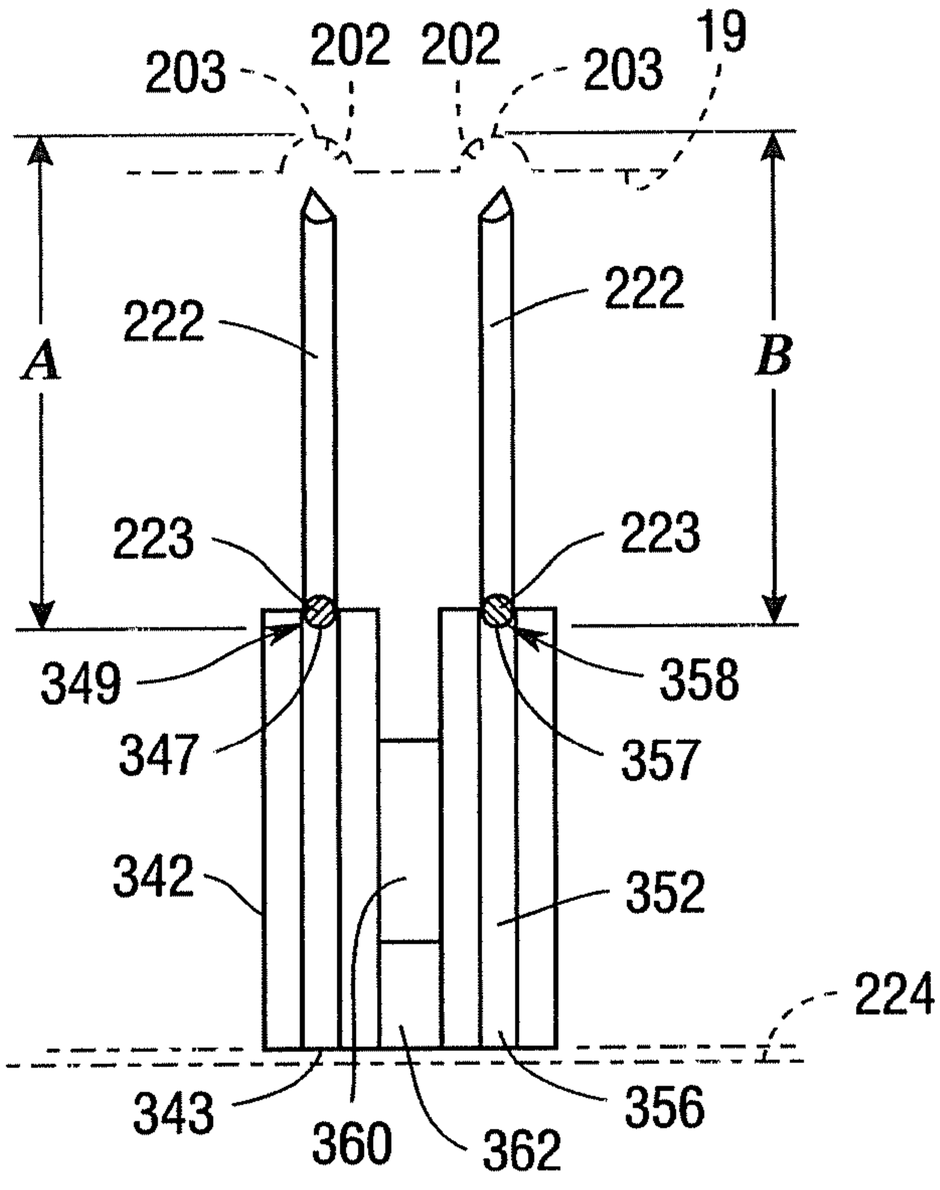
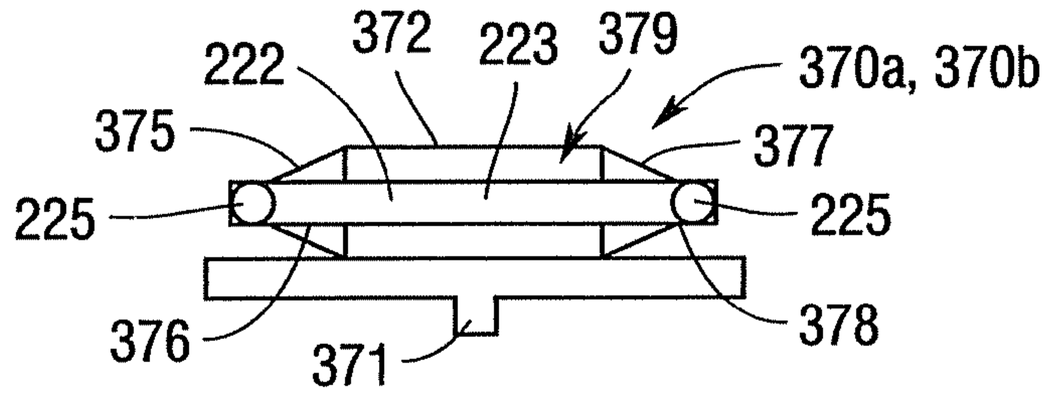


Fig.15A

Fig.17



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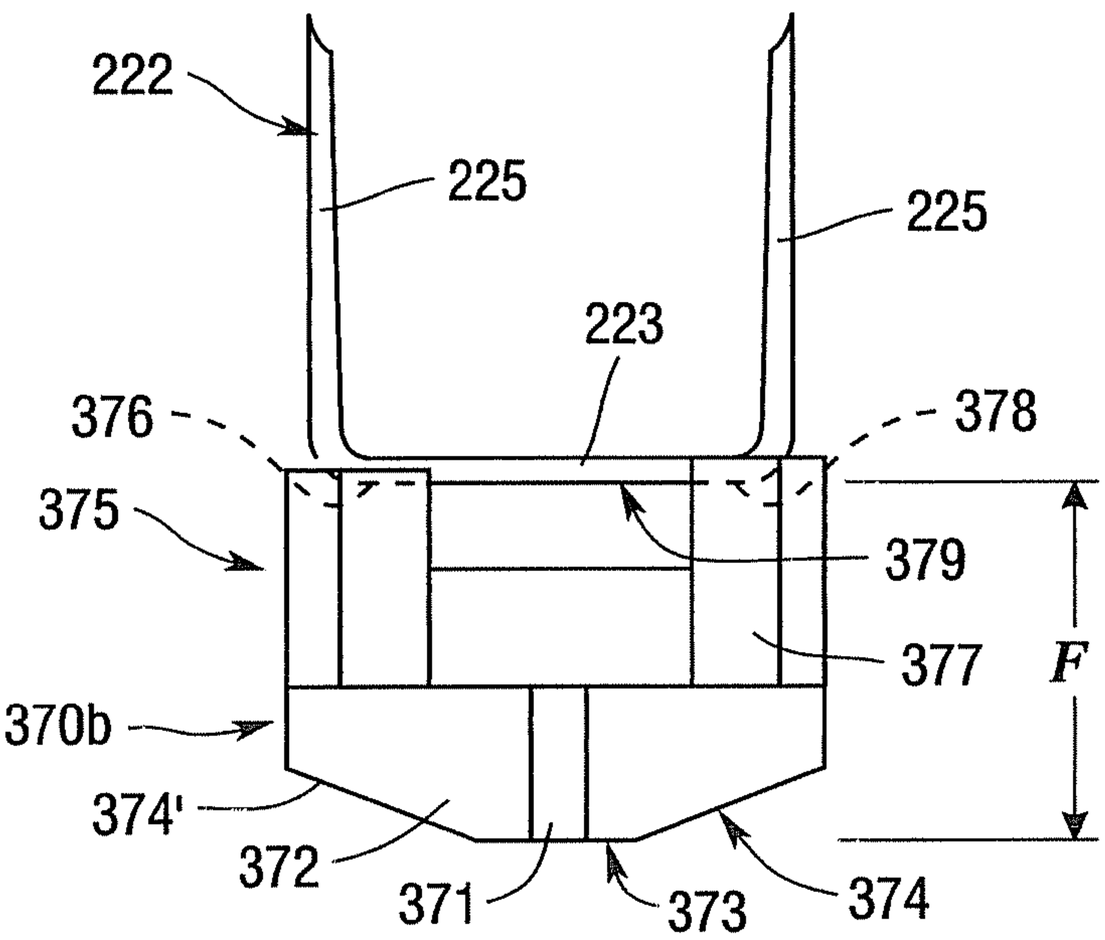

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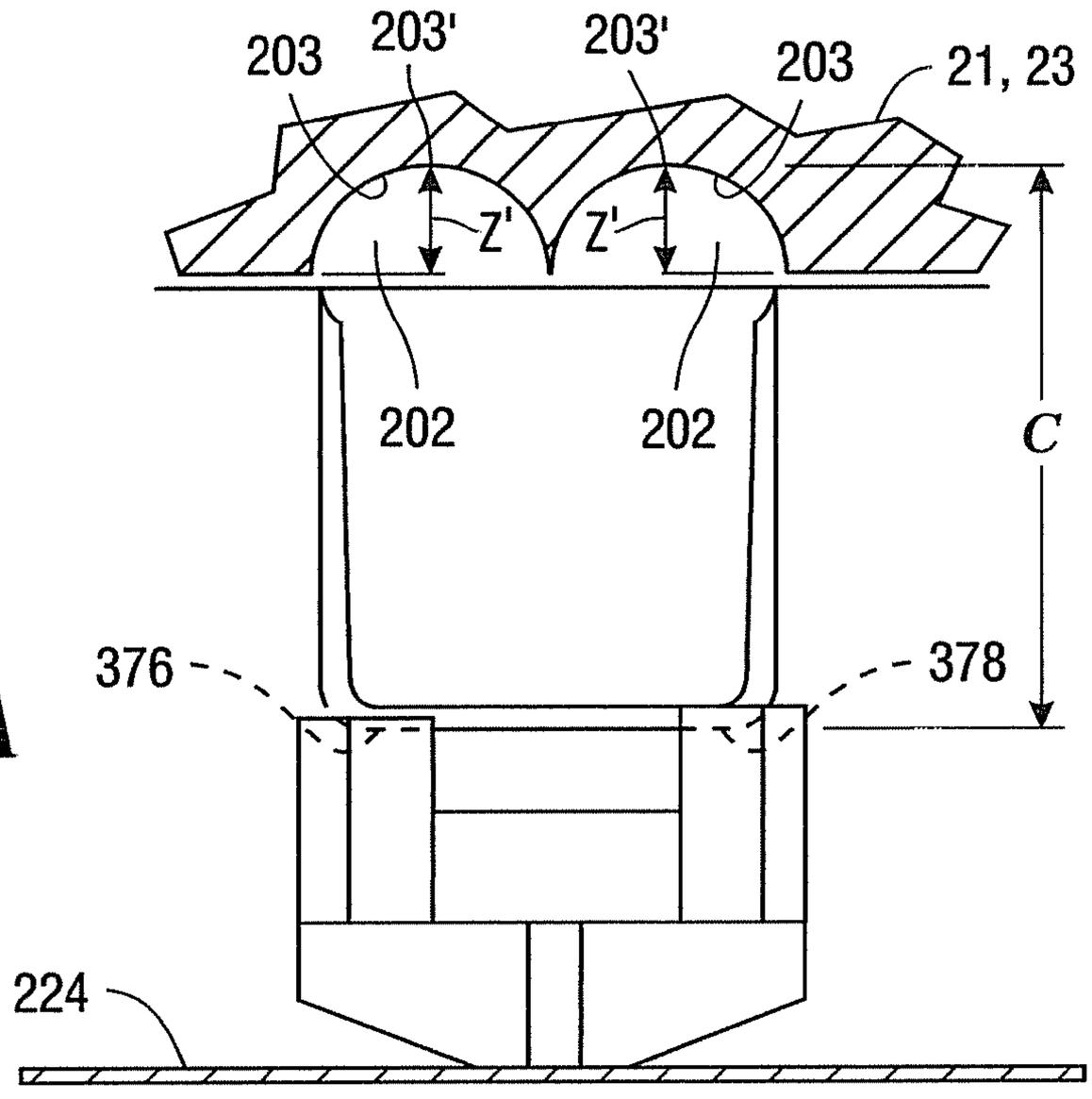

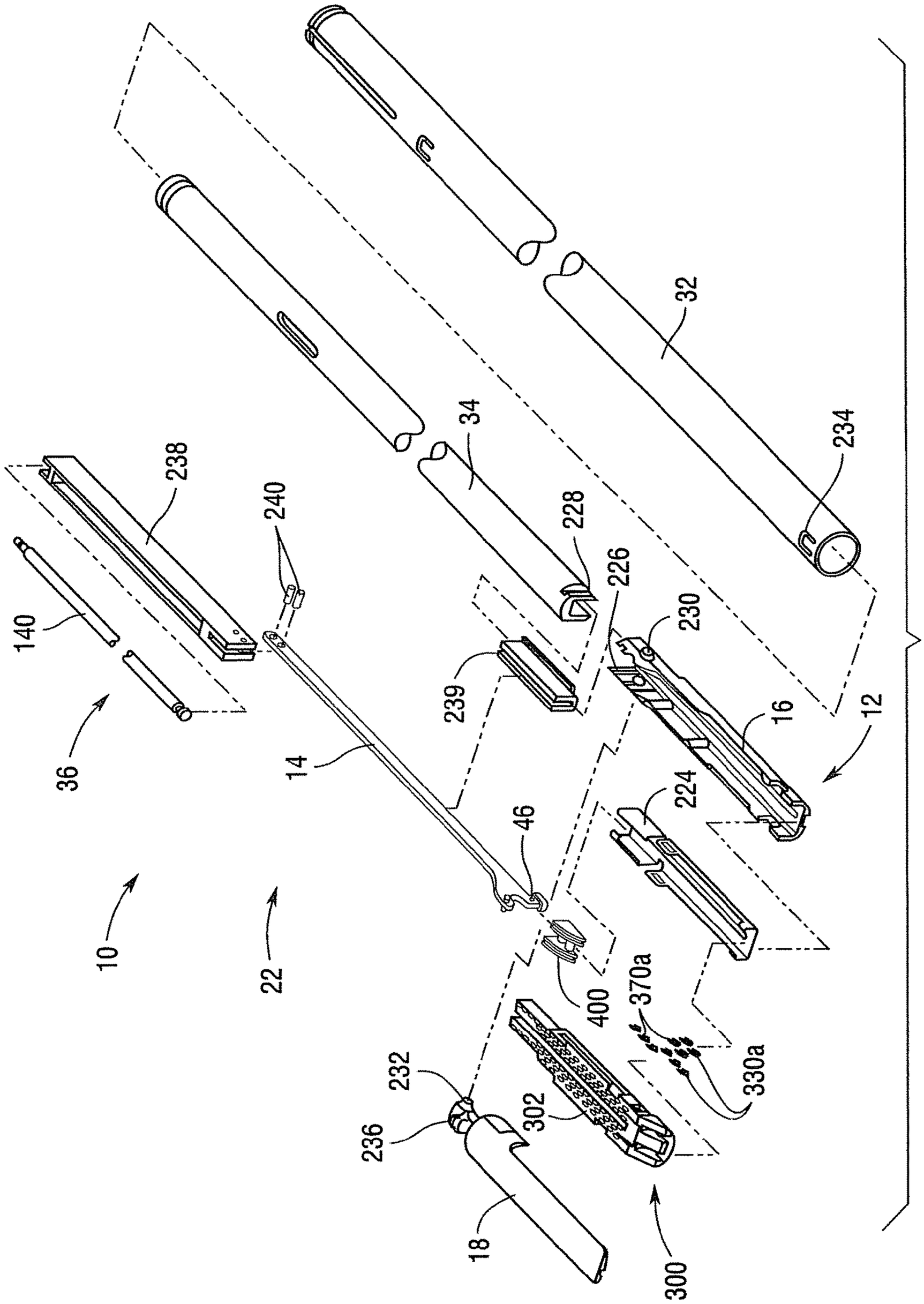
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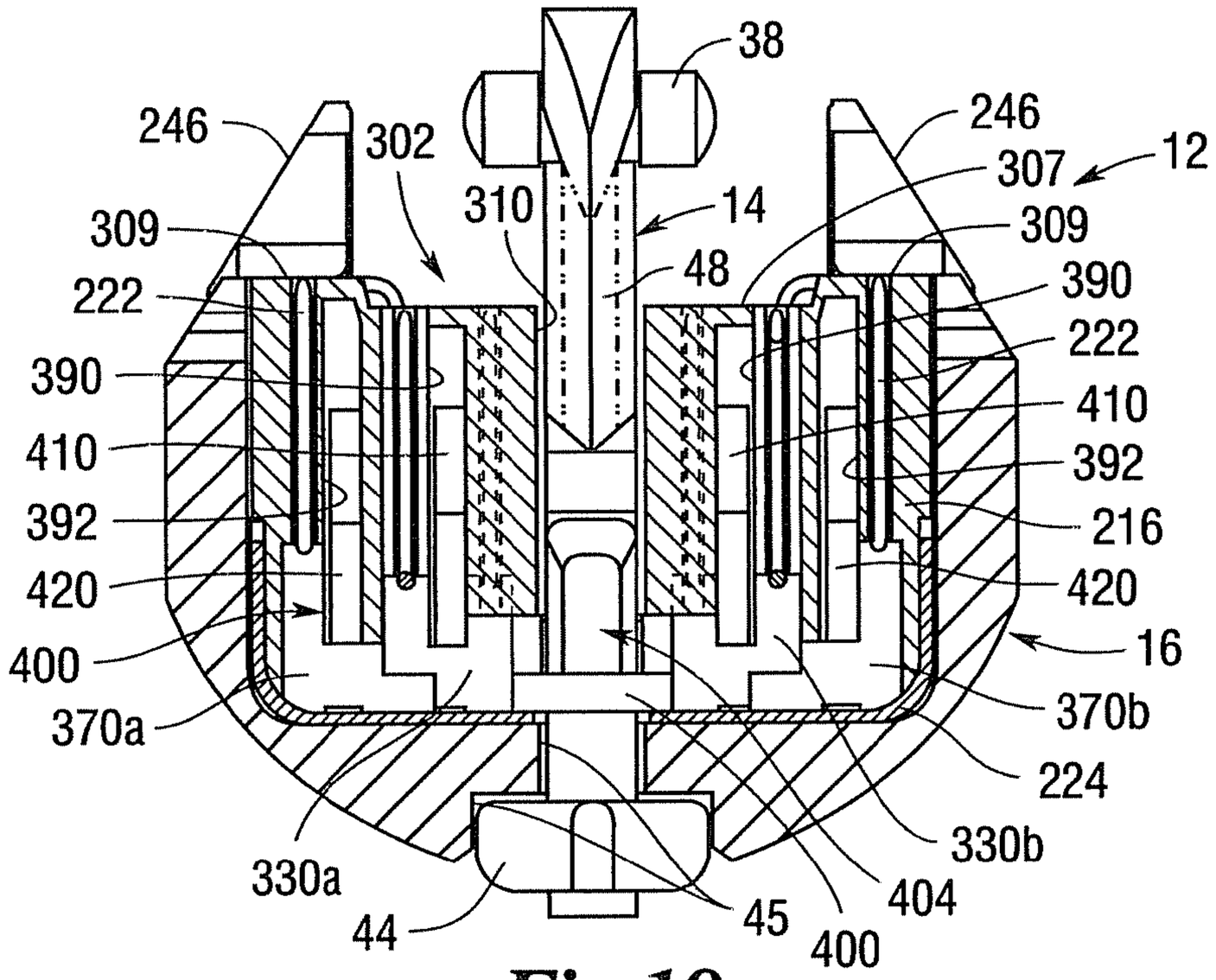
Fig.18



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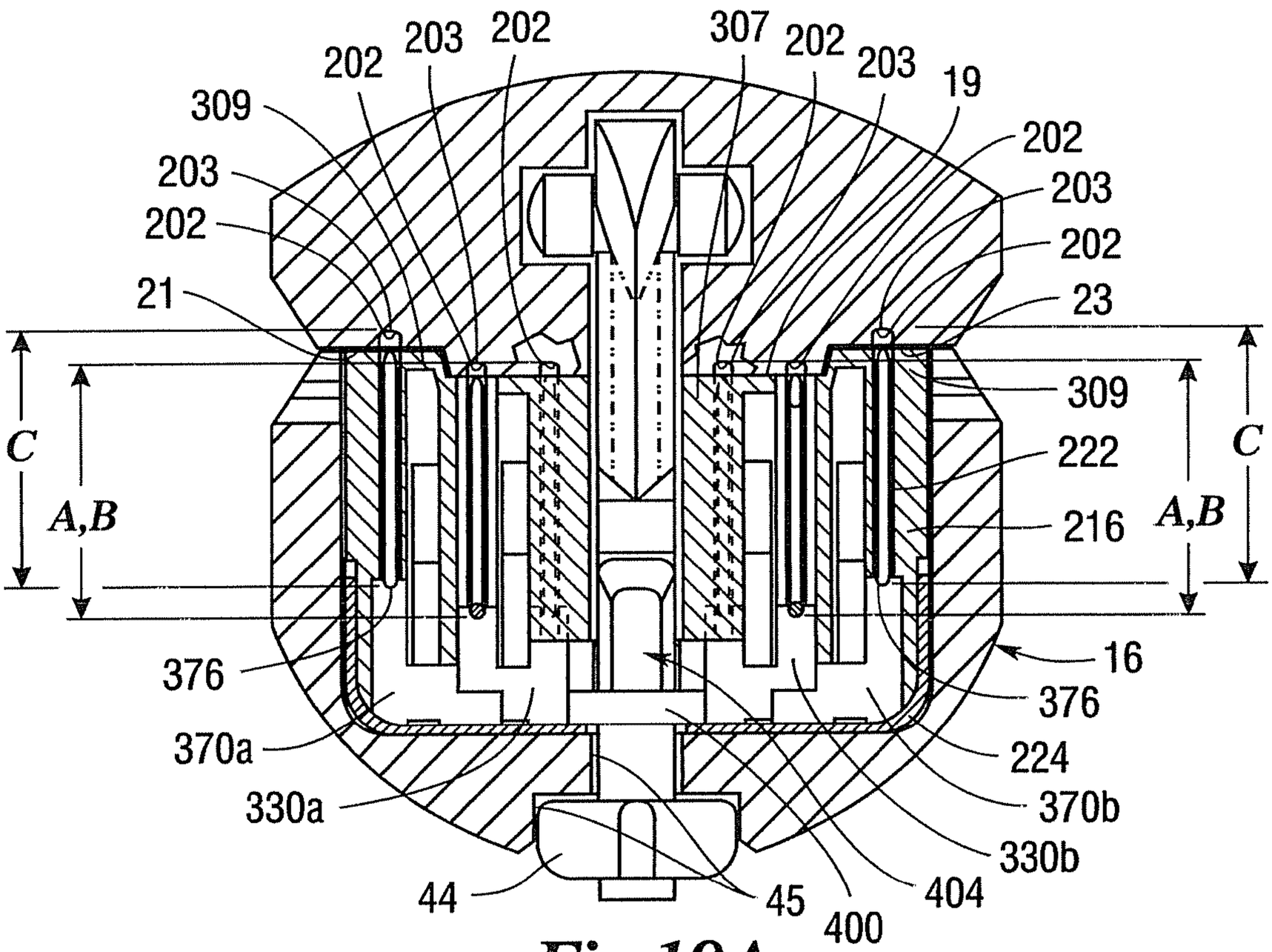

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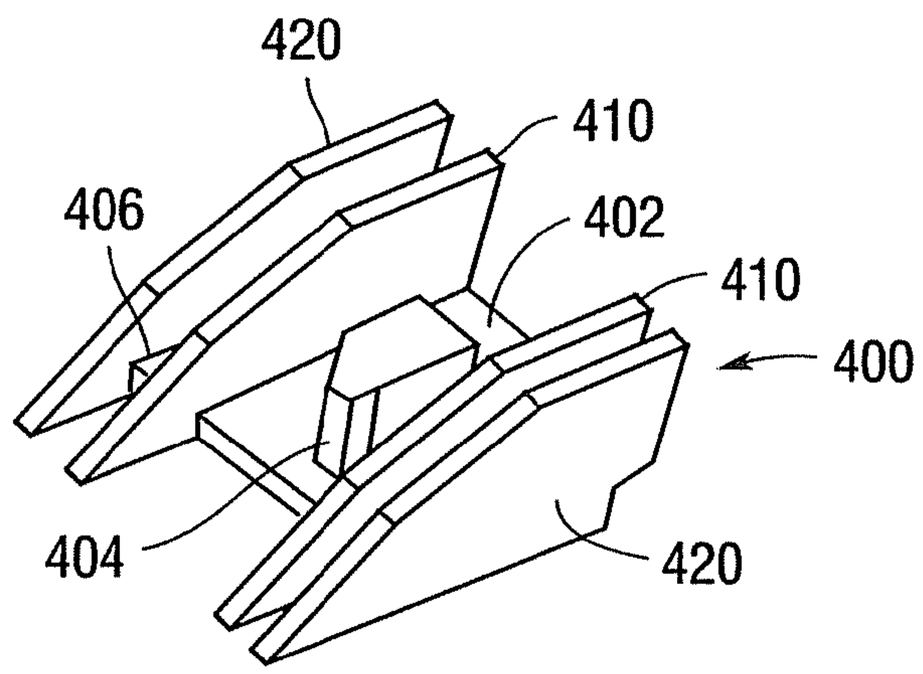

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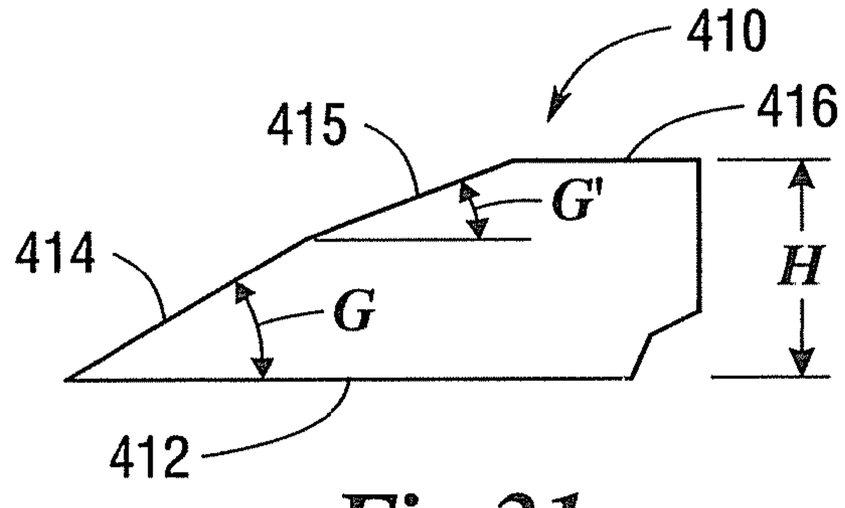

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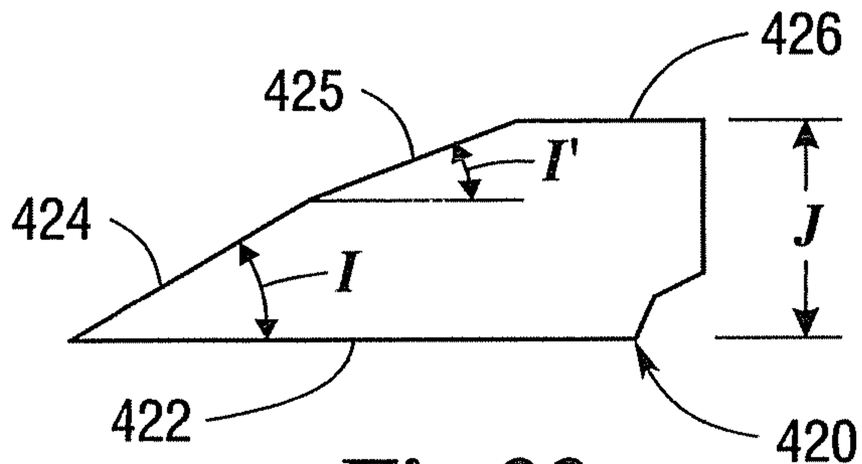

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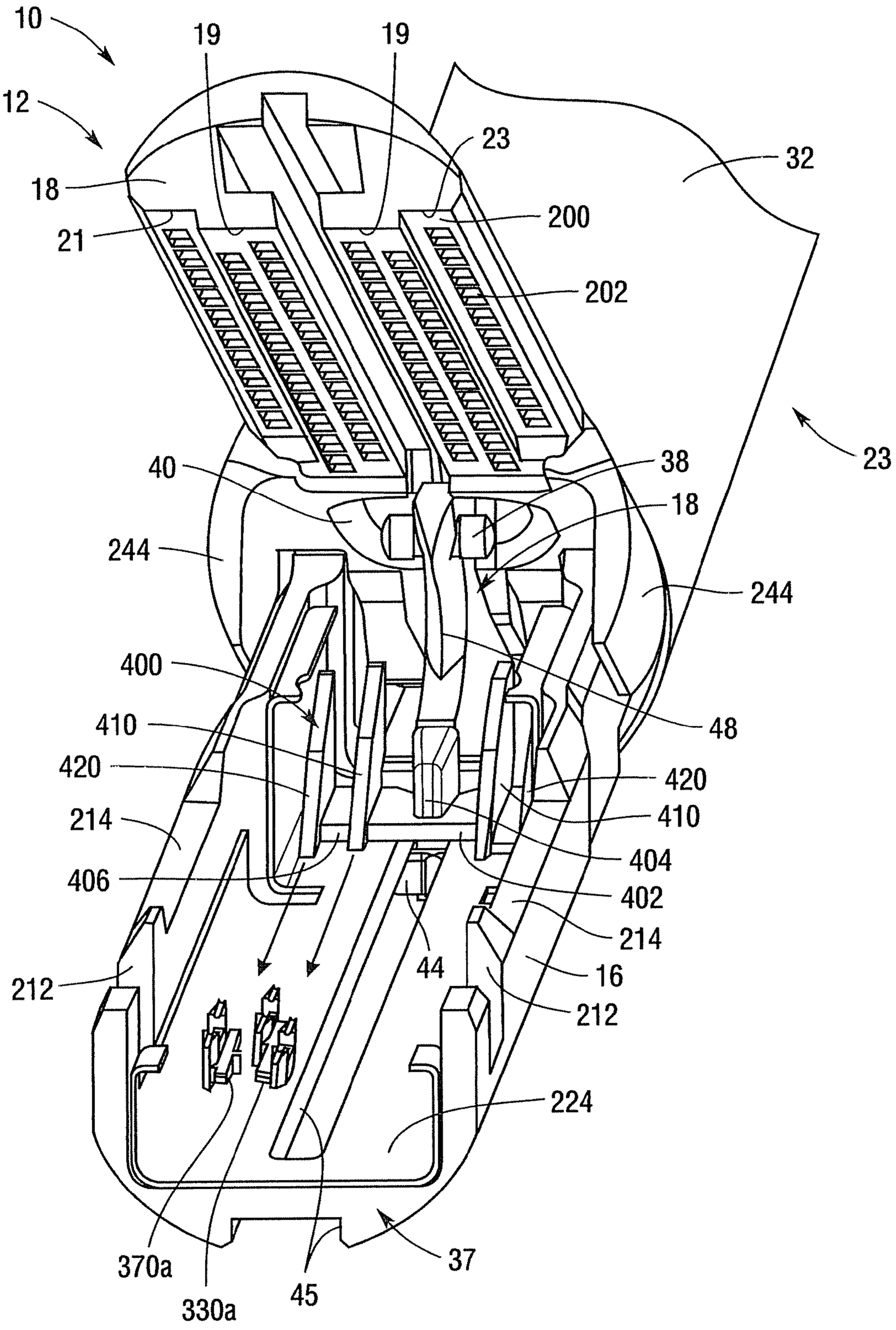
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Fig.23

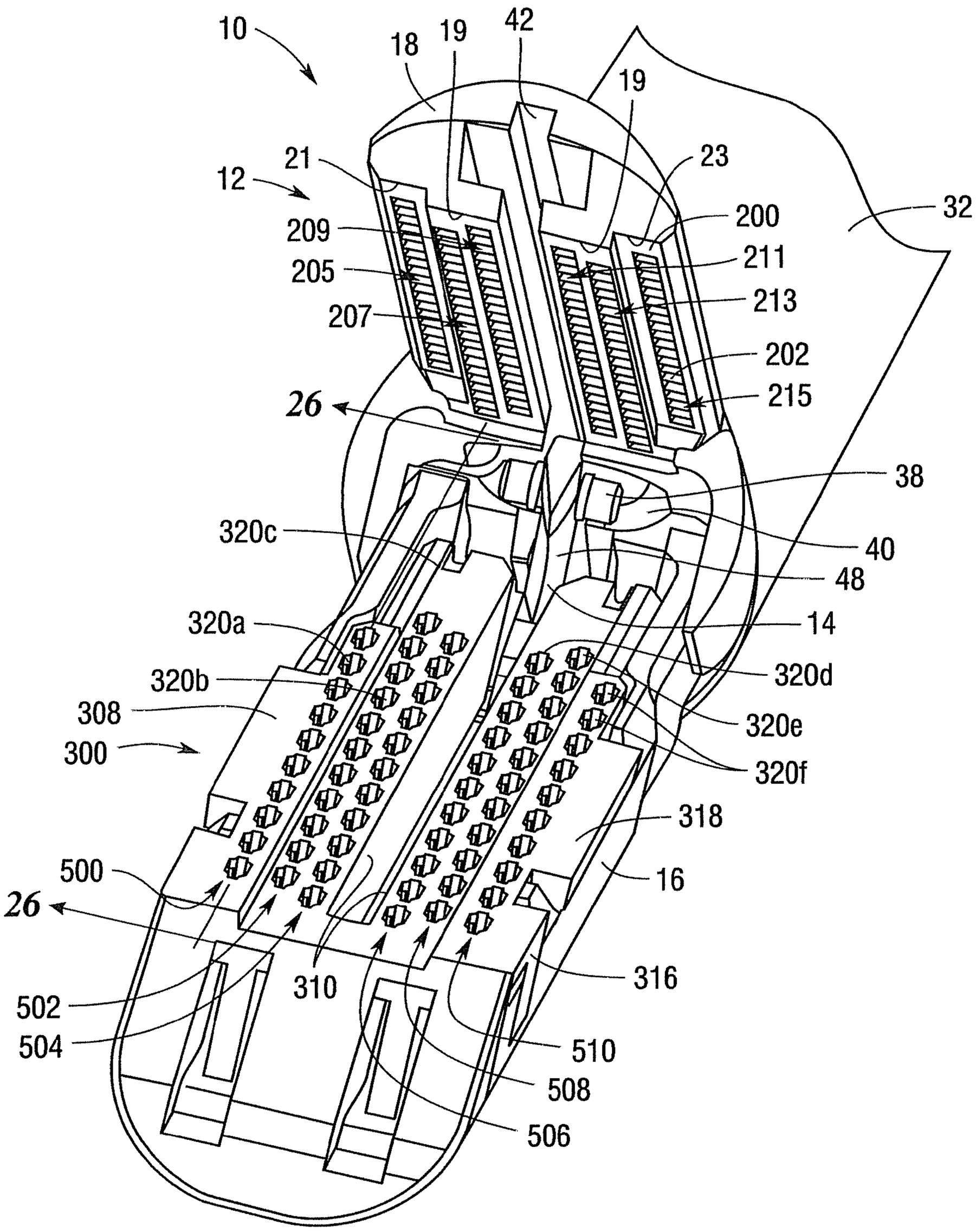
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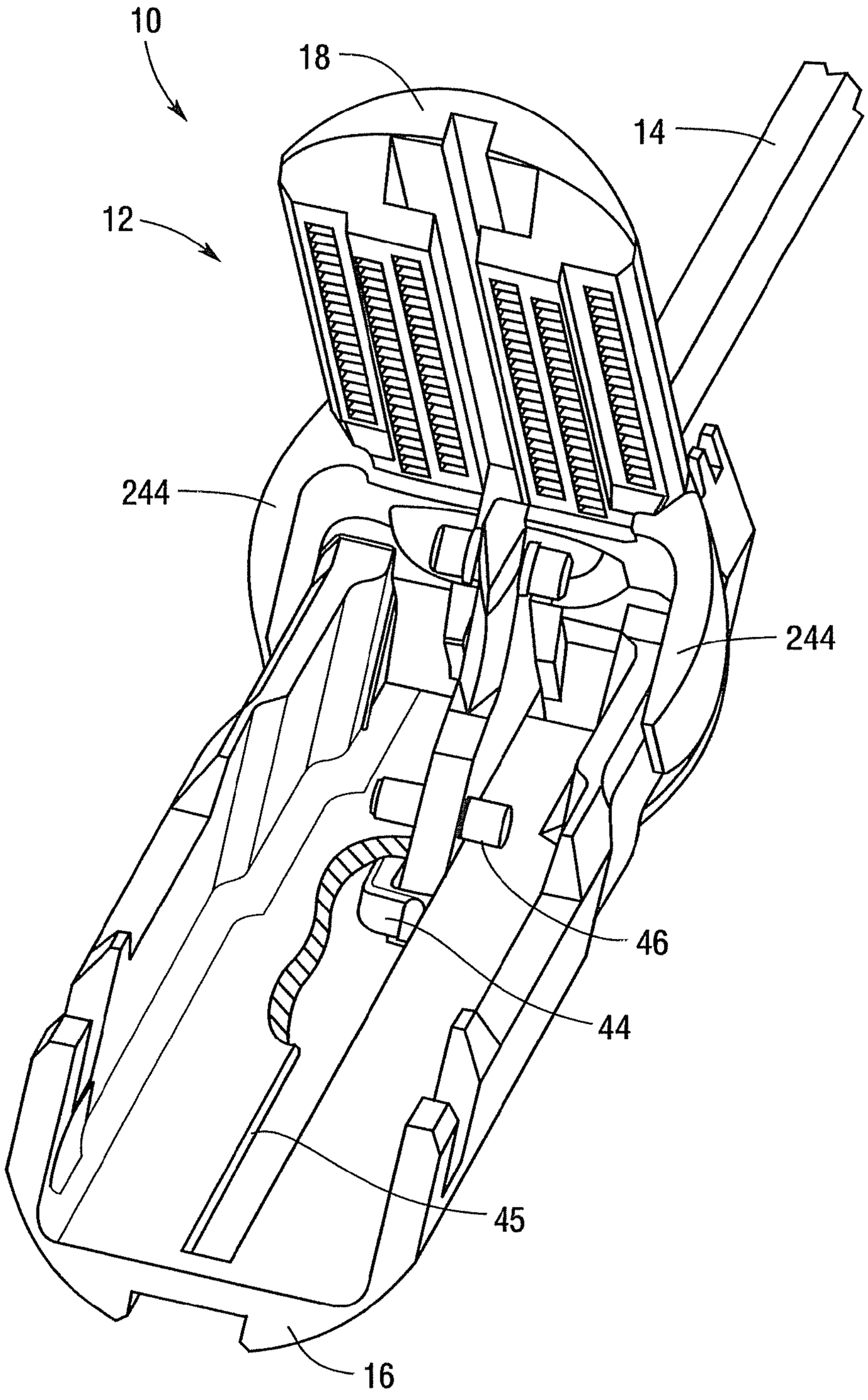
Fig.24



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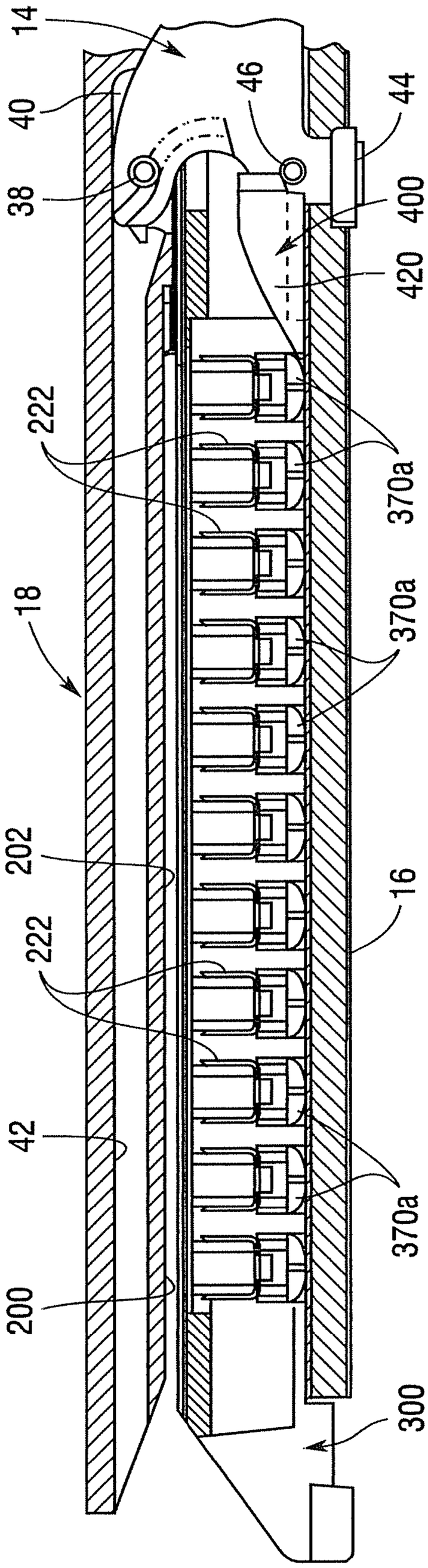

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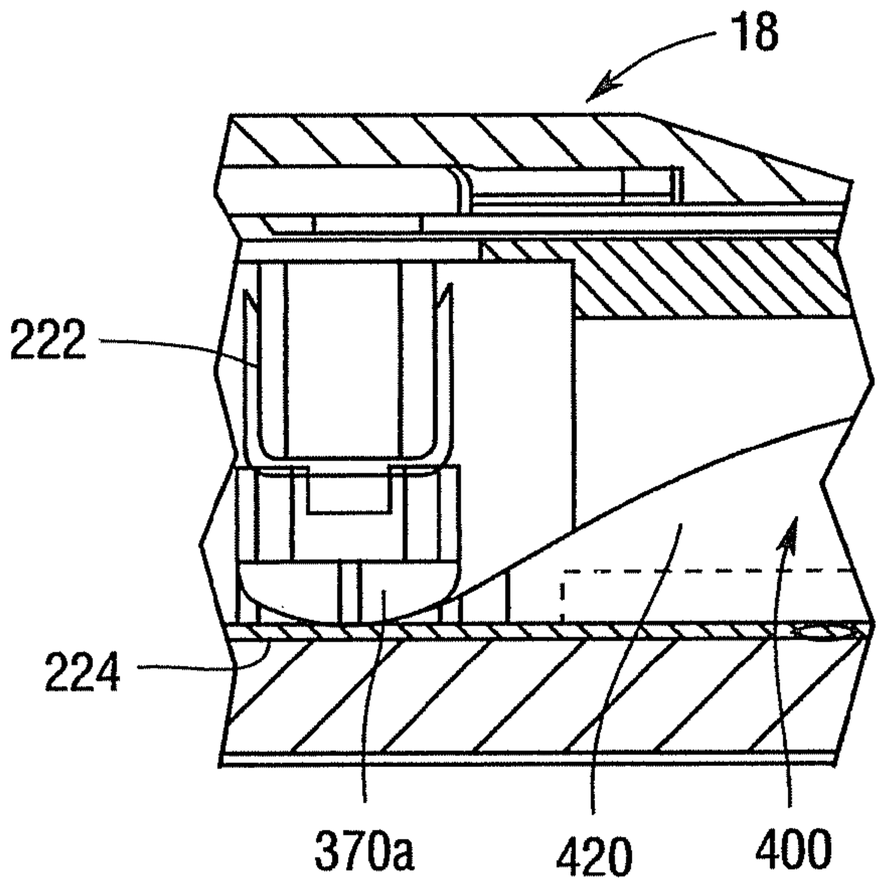
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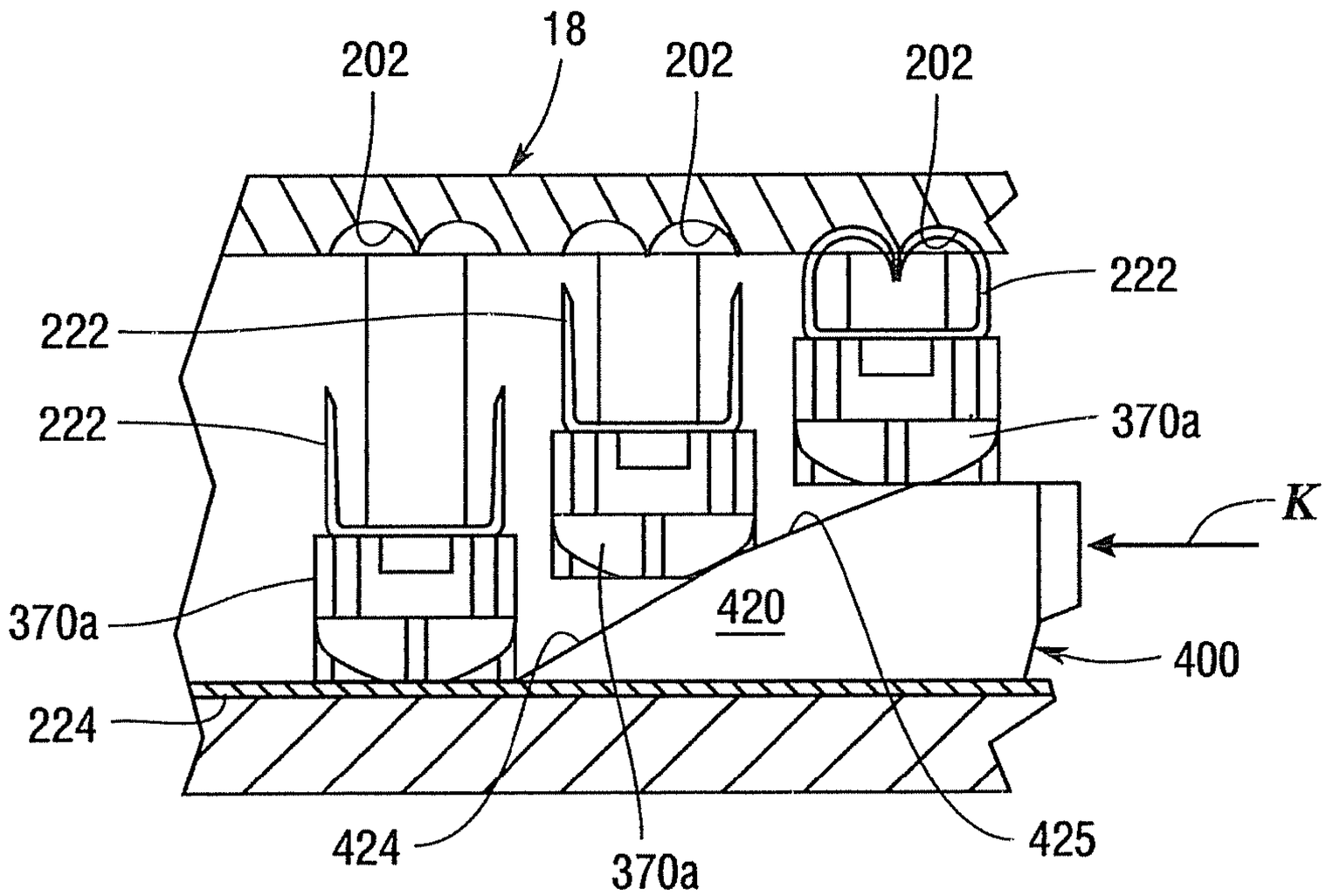
Fig.27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370a
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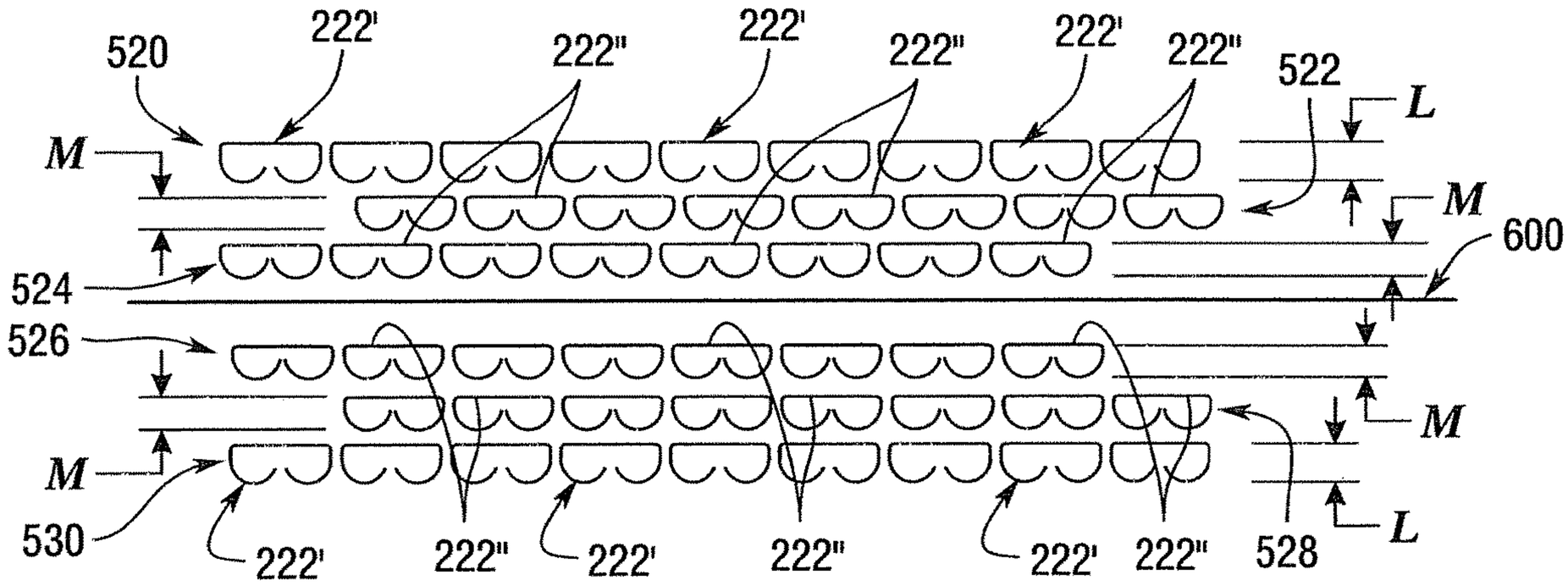
Fig.28



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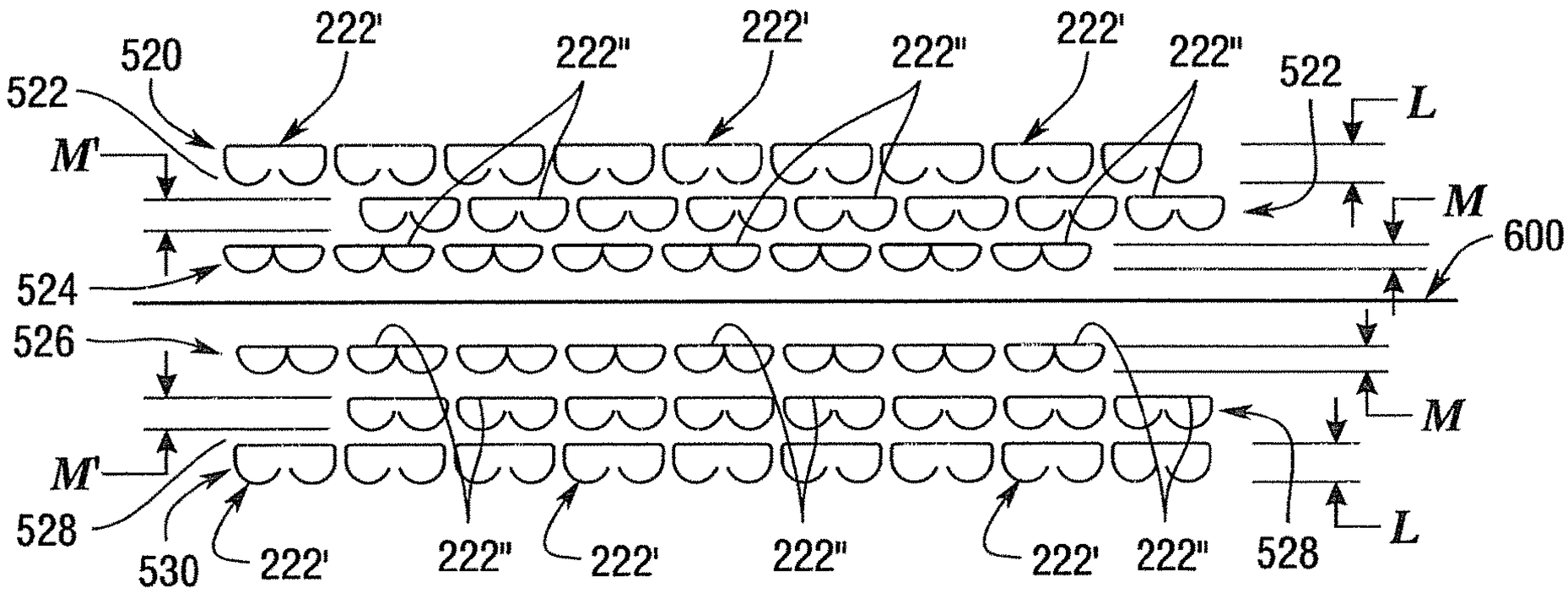

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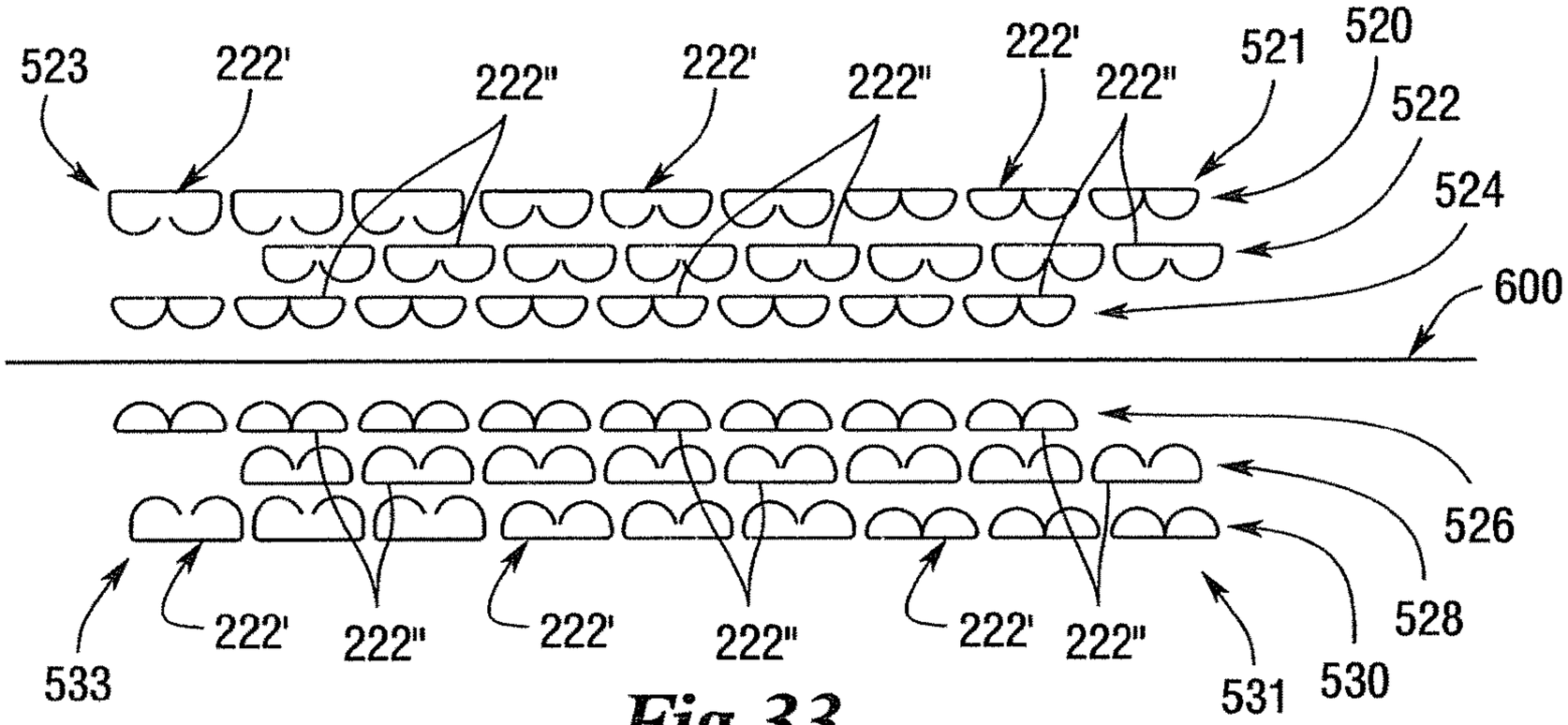

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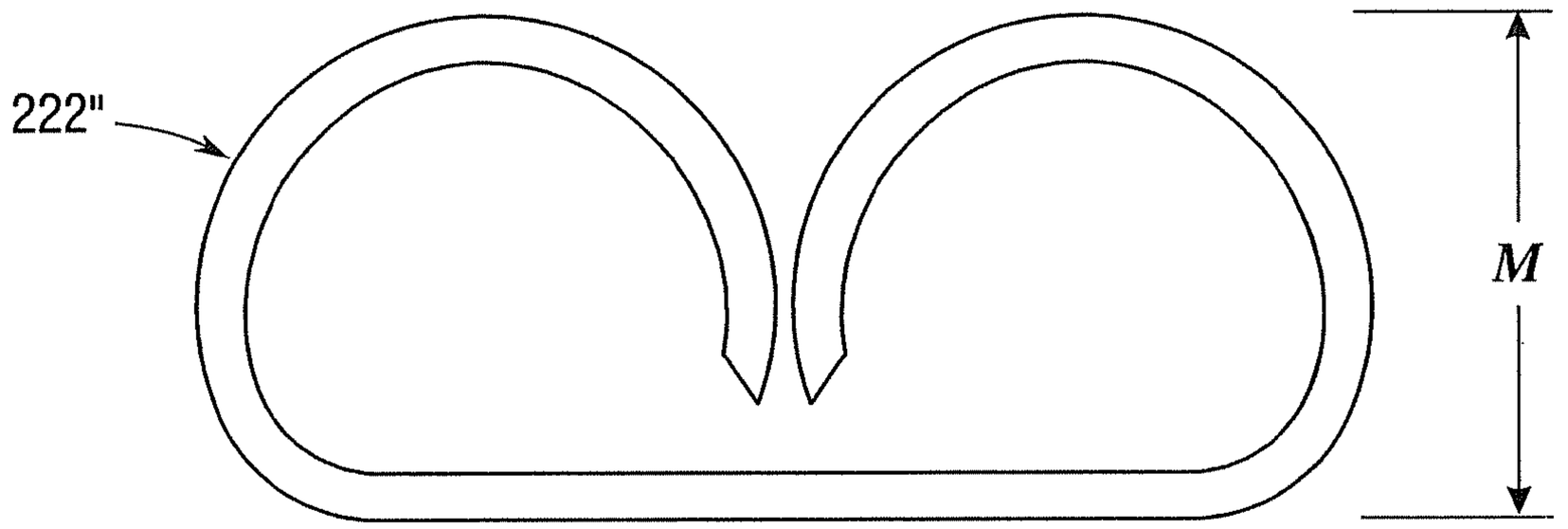

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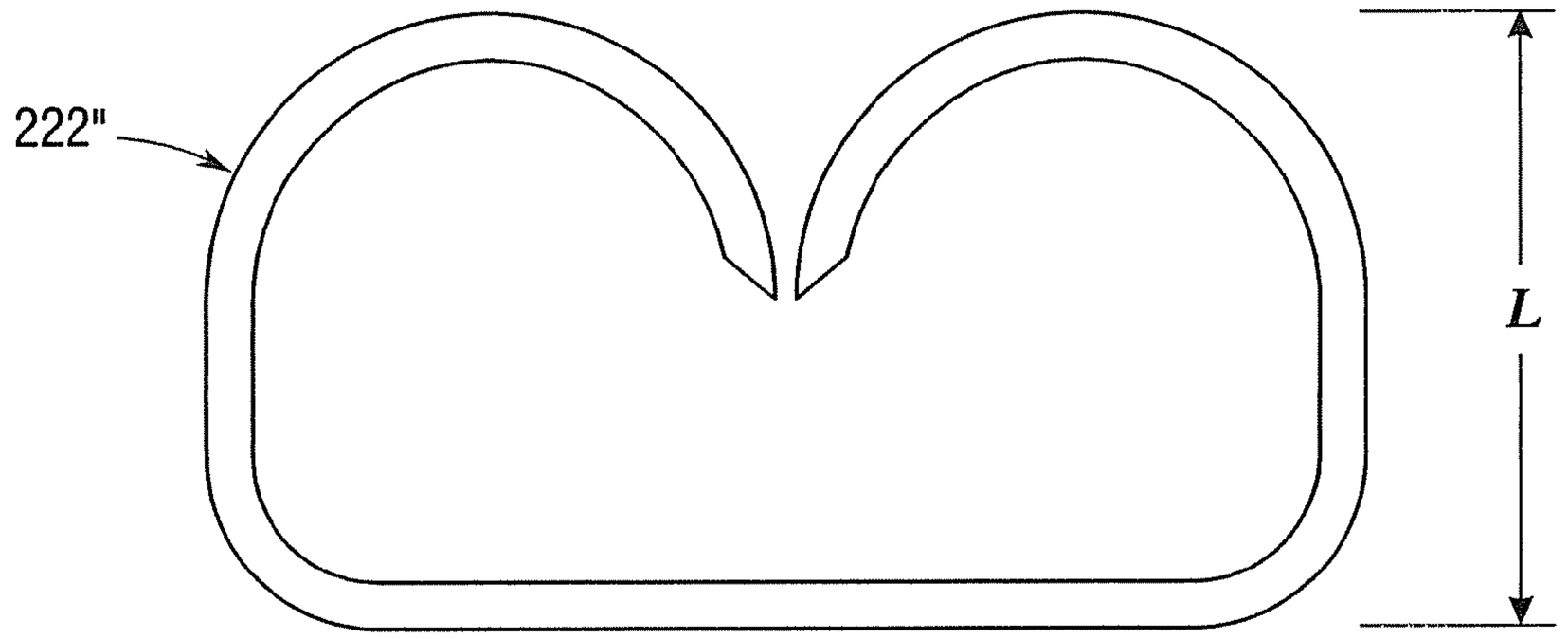

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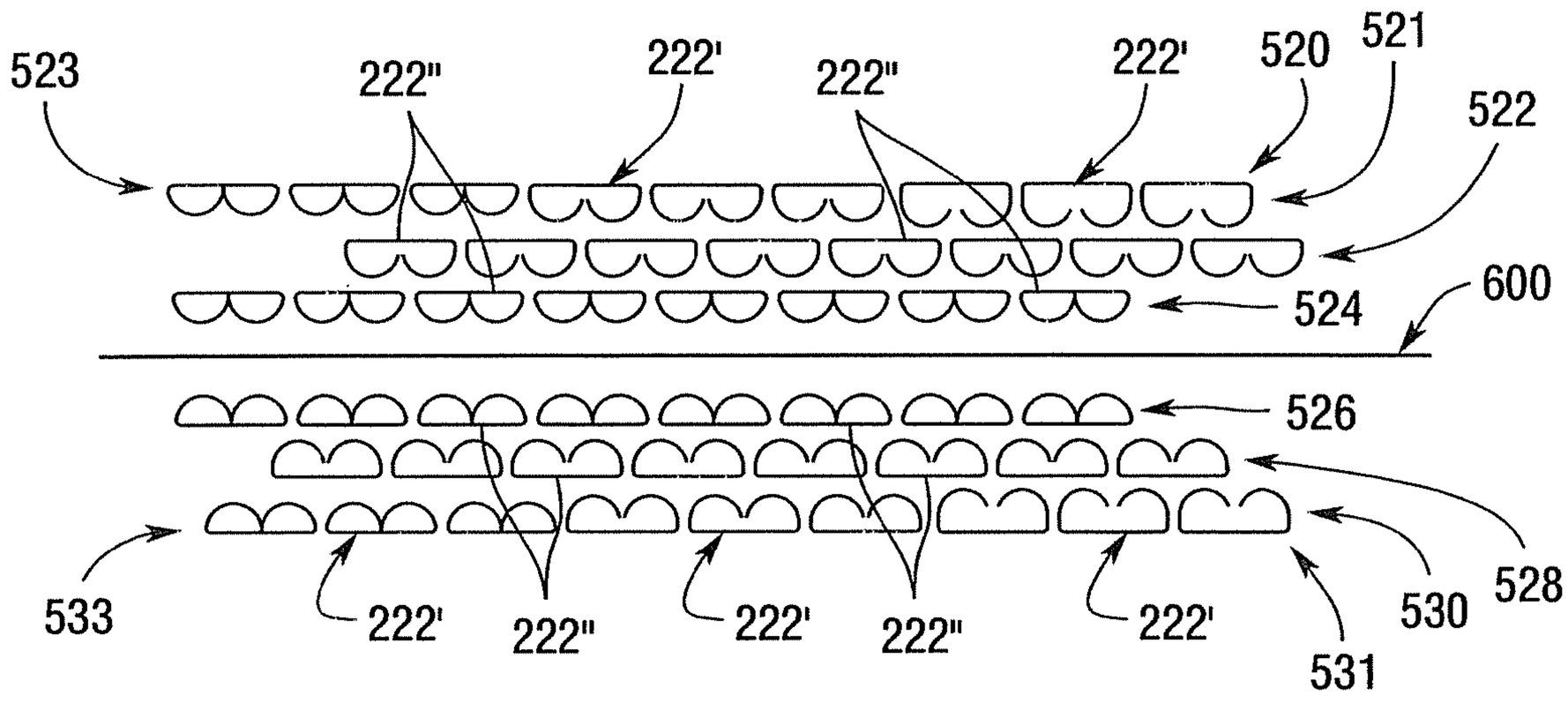
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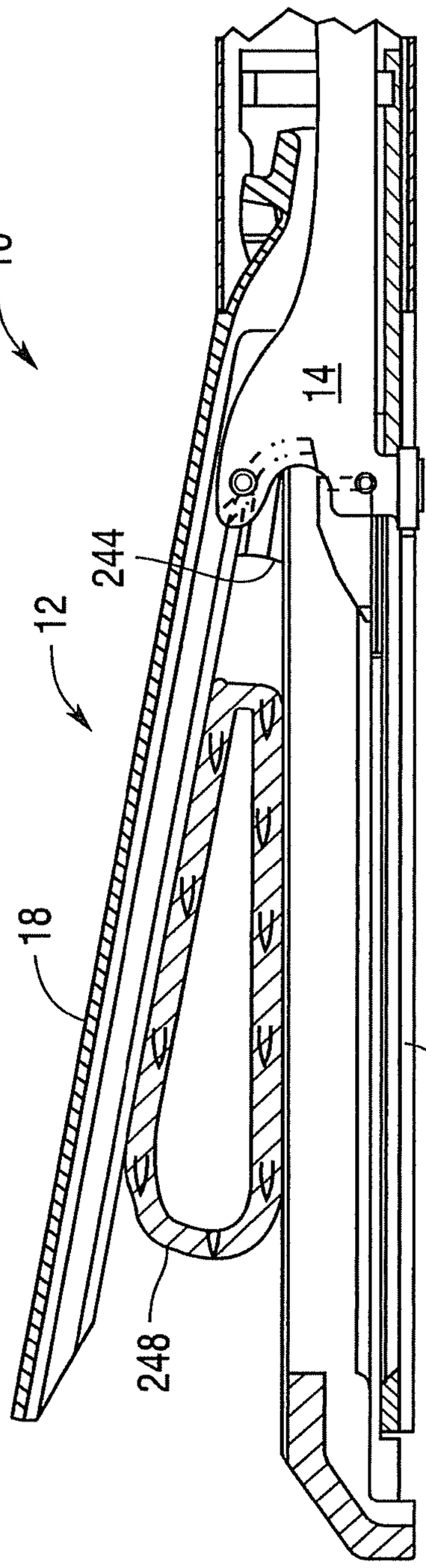
530
528

Fig.34



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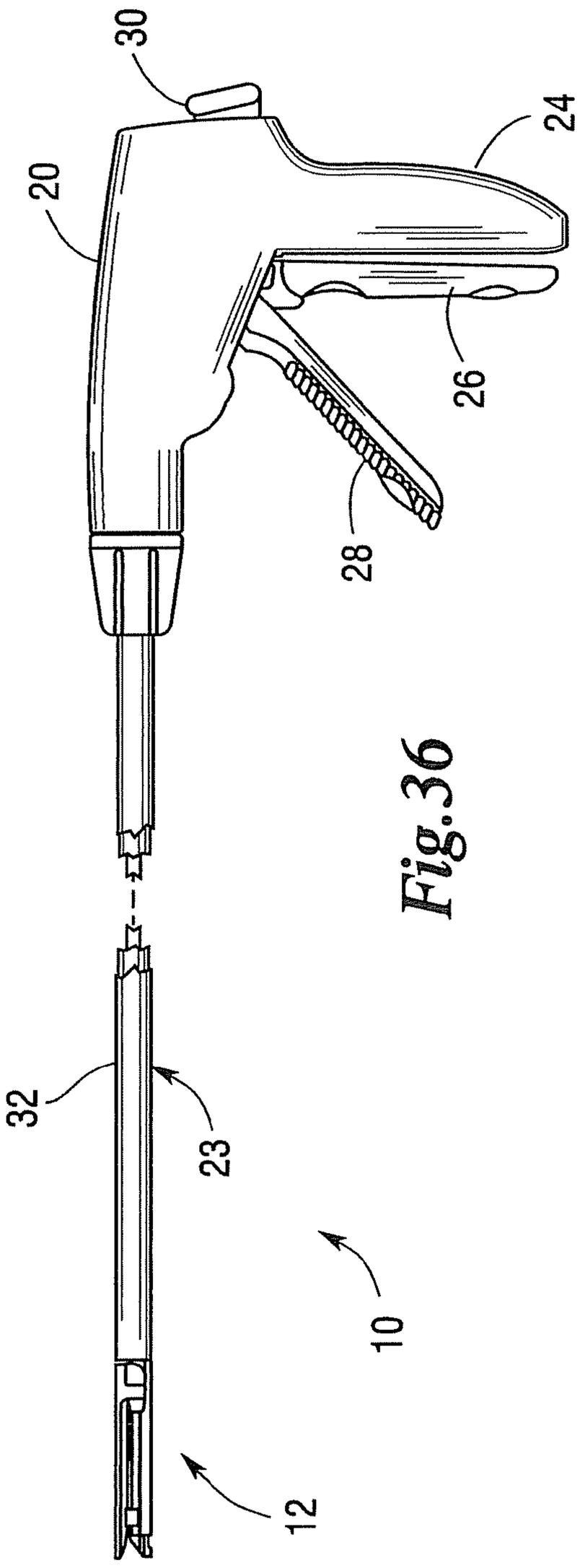

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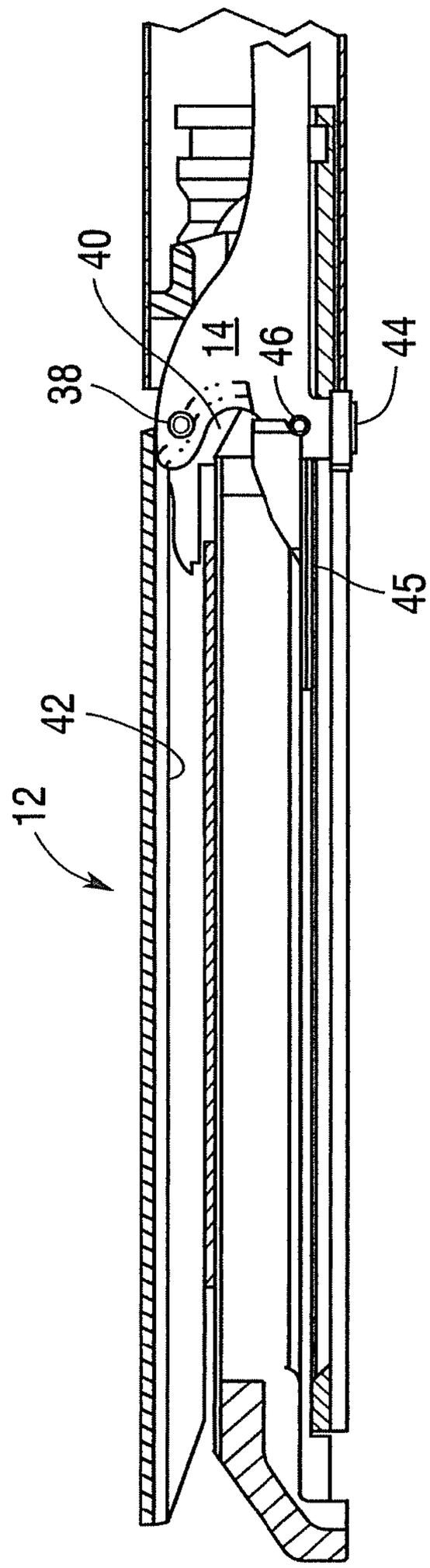

Fig.37

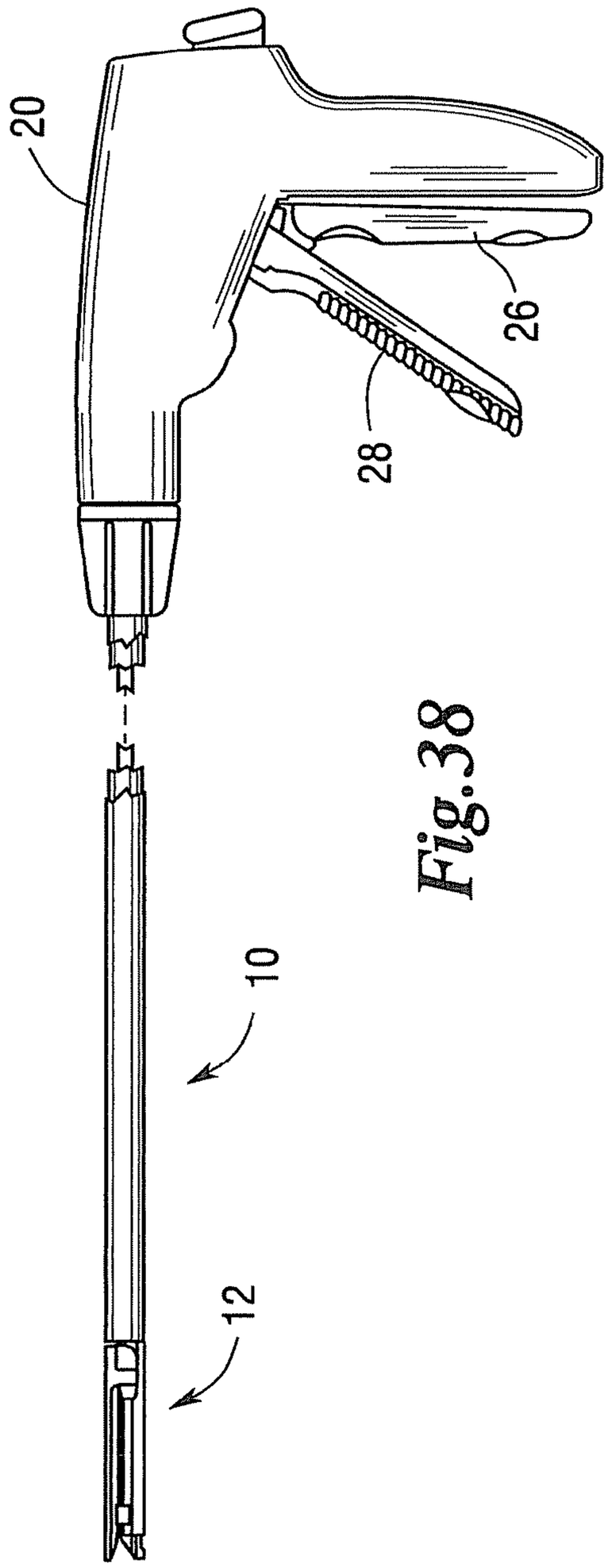

Fig.38

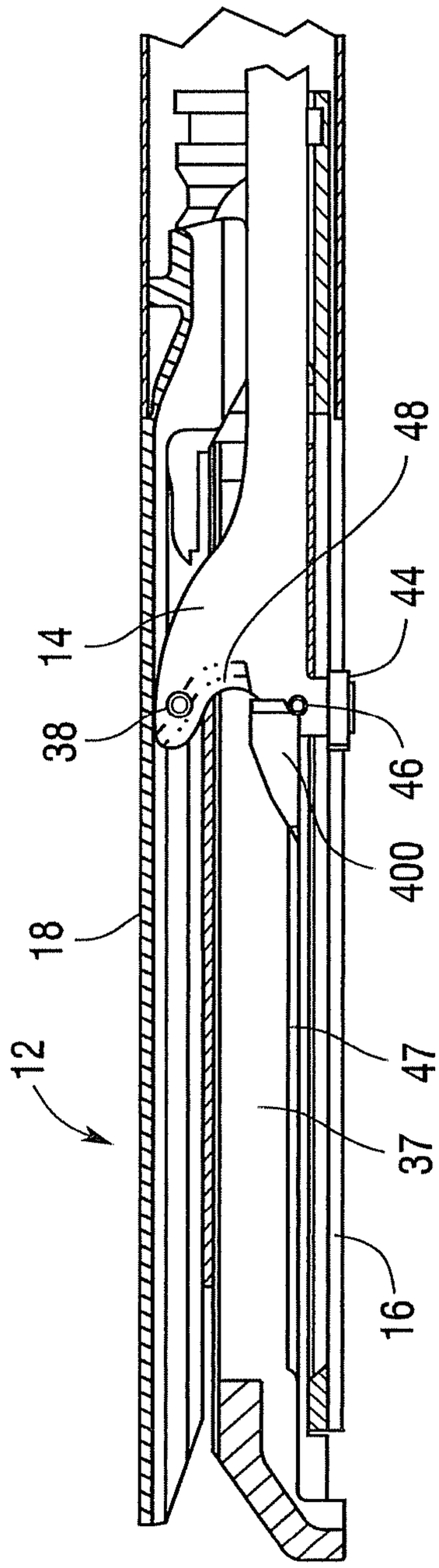

Fig.39

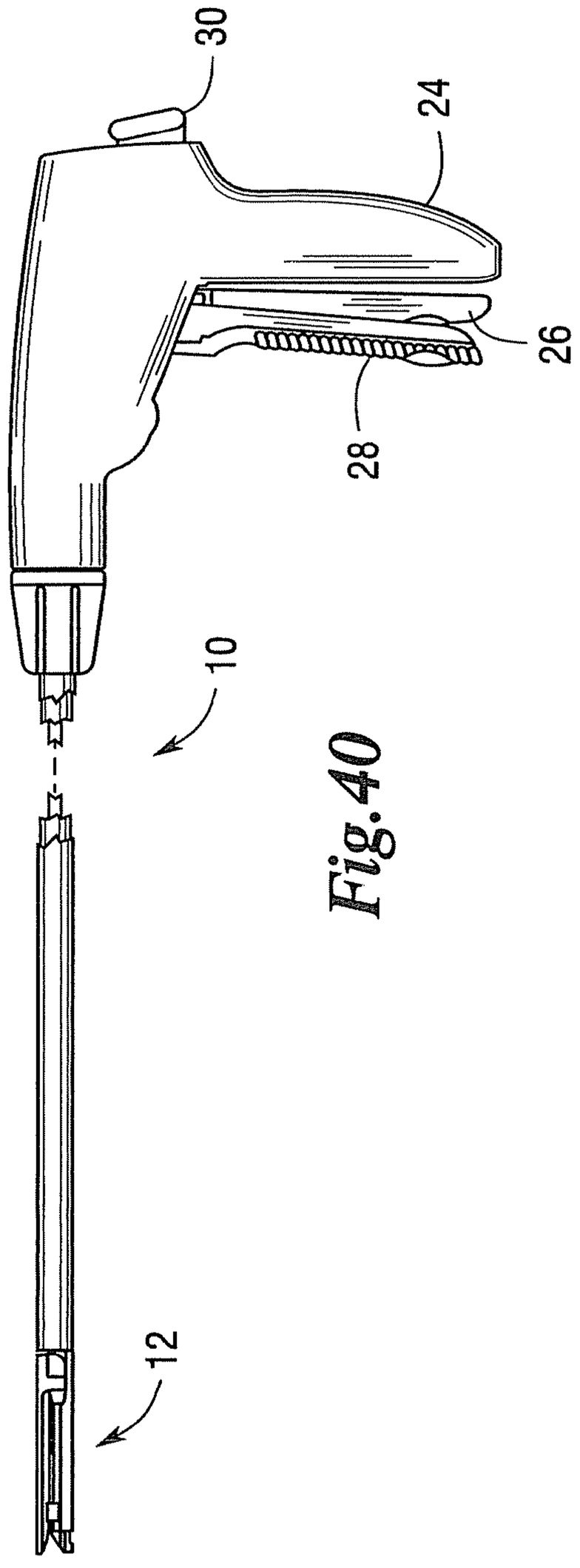

Fig. 40

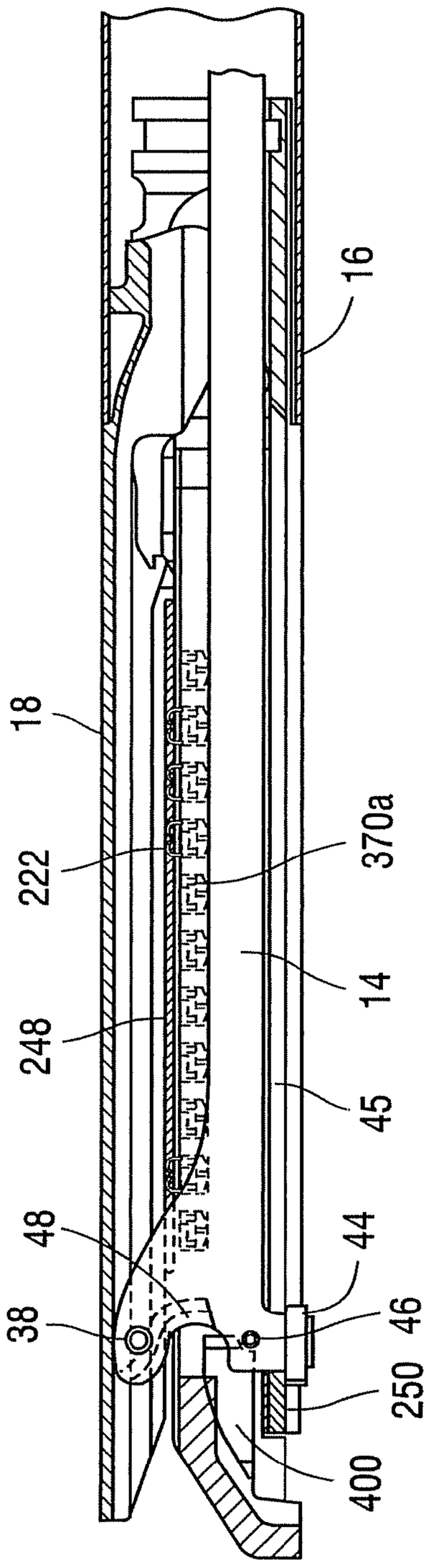

Fig. 41

STAPLE CARTRIDGES FOR FORMING STAPLES HAVING DIFFERING FORMED STAPLE HEIGHTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application claiming priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 16/371,711, entitled STAPLE CARTRIDGES FOR FORMING STAPLES HAVING DIFFERING FORMED STAPLE HEIGHTS, filed Apr. 1, 2019, now U.S. Patent Application Publication No. 2019/0274677, which is a continuation application claiming priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 15/073,168, entitled STAPLE CARTRIDGES FOR FORMING STAPLES HAVING DIFFERING FORMED STAPLE HEIGHTS, filed Mar. 17, 2016, which issued on Apr. 2, 2019 as U.S. Pat. No. 10,245,032, which is a continuation application claiming priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 13/795,122, entitled STAPLE CARTRIDGES FOR FORMING STAPLES HAVING DIFFERING FORMED STAPLE HEIGHTS, filed Mar. 12, 2013, which issued on May 3, 2016 as U.S. Pat. No. 9,326,768, which is a continuation application claiming priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 12/695,359, entitled SURGICAL STAPLING DEVICES FOR FORMING STAPLES WITH DIFFERENT FORMED HEIGHTS, filed on Jan. 28, 2010, which issued on Jun. 18, 2013 as U.S. Pat. No. 8,464,923, which is a continuation application claiming priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 11/216,562, entitled STAPLE CARTRIDGES FOR FORMING STAPLES HAVING DIFFERING FORMED STAPLE HEIGHTS, filed Aug. 31, 2005, which issued on Mar. 2, 2010 as U.S. Pat. No. 7,669,746, the entire disclosures of which are hereby incorporated by reference herein.

FIELD OF THE INVENTION

The present invention relates in general to stapling instruments that are capable of applying lines of staples and, more particularly, to improvements relating to staple cartridges for use with surgical stapling instruments that are capable of applying lines of staples having differing formed staple heights to tissue while simultaneously cutting the tissue.

BACKGROUND OF THE INVENTION

Surgical staplers have been used in the prior art to simultaneously make a longitudinal incision in tissue and apply lines of staples on opposing sides of the incision. Such instruments commonly include a pair of cooperating jaw members that, if the instrument is intended for endoscopic or laparoscopic applications, are capable of passing through a cannula passageway. One of the jaw members receives a staple cartridge having at least two laterally spaced rows of staples. The other jaw member defines an anvil having staple-forming pockets aligned with the rows of staples in the cartridge. The instrument includes a plurality of reciprocating wedges that, when driven distally, pass through openings in the staple cartridge and engage drivers supporting the staples to effect the firing of the staples toward the anvil.

An example of a surgical stapler suitable for endoscopic applications is described in U.S. Patent Application Publication No. 2004/0232196, now U.S. Pat. No. 7,000,818, the disclosure of which is herein incorporated by reference in its entirety. In use, a clinician is able to close the jaw members of the stapler upon tissue to position the tissue prior to firing. Once the clinician has determined that the jaw members are properly gripping tissue, the clinician can then fire the surgical stapler, thereby severing and stapling the tissue. The simultaneous severing and stapling avoids complications that may arise when performing such actions sequentially with different surgical tools that respectively only sever or staple.

Whenever a transection of tissue is across an area of varied tissue composition, it would be advantageous for the staples that are closest to the cut line to have one formed height that is less than the formed height of those staples that are farthest from the cut line. In practice, the rows of inside staples serve to provide a hemostatic barrier, while the outside rows of staples with larger formed heights provide a cinching effect where the tissue transitions from the tightly compressed hemostatic section to the non-compressed adjacent section. In other applications, it may be useful for the staples in a single line of staples to have differing formed heights.

U.S. Pat. Nos. 4,941,623 and 5,027,834 disclose surgical stapler and cartridge arrangements that employ staples that have different prong lengths to ultimately achieve lines of staples that have differing formed heights. Likewise, WO 2003/094747 A1 discloses a surgical stapler and cartridge that has six rows of staples wherein the outer two rows of staples comprise staples that are larger than the staples employed in the inner two rows and middle rows of staples. Thus, all of these approaches require the use of different sizes of staples in the same cartridge.

Consequently, a significant need exists for an improved cartridge for a stapling instrument that can form lines of staples that have differing formed heights without the need to employ different sizes of staples in the same cartridge.

BRIEF SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention there is a provided a staple cartridge for use with a stapling device that has an actuator that is selectively actuatable in an axial direction and an anvil portion that is selectively movable between open and closed positions. In one embodiment, the staple cartridge comprises a cartridge body that is supportable within the stapling device for selective confronting relationship with the anvil portion thereof when in a closed position. The cartridge body is configured to axially receive the actuator therein. The staple cartridge further comprises at least one first staple driver that is movably supported within the cartridge body for contact by the actuator such that, as the actuator is axially advanced through the cartridge body, the first staple drivers are driven in a direction towards the anvil when the anvil is in the closed position. Each of the first staple drivers has a first staple support cradle therein for supporting a staple thereon. The first staple support cradle is located a first staple forming distance from a corresponding portion of the closed anvil. At least one second staple driver is movably supported within the cartridge body for contact by the actuator such that as the actuator is axially advanced through the cartridge body, the second staple drivers are driven in the direction towards the closed anvil. Each second staple driver has a second staple support cradle therein for supporting another staple thereon. The second staple support cradle is located a second staple forming distance from another portion of the closed anvil. The second staple forming distance differs from the first staple forming distance.

In accordance with another embodiment of the present invention, there is provided a staple cartridge for use with a surgical instrument that has an end effector that includes an anvil portion that is pivotally attached thereto for travel between open and closed positions. The instrument further includes a firing bar that is selectively axially reciprocatable within the end effector. One embodiment of the staple cartridge comprises a cartridge body that is sized to be supported within the end effector. The cartridge body has a longitudinally extending slot therein for reciprocatingly receiving the firing bar therein. The cartridge further comprises a first plurality of inside staple drivers that are axially aligned in a first row of inside staple drivers on a first side of the longitudinally extending slot in the body. A second plurality of inside staple drivers is also axially aligned in a second row of inside staple drivers on a second side of the longitudinally extending slot. The inside staple drivers are movably supported within the cartridge body for selective movement towards the anvil when the anvil is in a closed position. Each inside staple driver has a first staple support cradle for supporting a staple thereon. The first staple support cradles are each located a first staple forming distance from a corresponding portion of the anvil when the anvil is in a closed position. The cartridge further comprises a first plurality of outside staple drivers that are axially aligned in a first row of outside staple drivers. The first row of outside staple drivers is located on the first side of the longitudinally extending slot and is adjacent to the first row of the inside staple drivers. The cartridge further includes a second plurality of outside staple drivers axially aligned in a second row of outside staple drivers. The second row of outside staple drivers is located on the second side of said elongated slot and is adjacent to the second row of inside staple drivers. Each of the outside staple drivers is movably supported within the cartridge body for selective driving movement towards the anvil when the anvil is in the closed position. Each of the outside staple drivers has a second staple support cradle for supporting another one of the staples thereon. Each second staple support cradle is located a second staple forming distance from another corresponding portion of the anvil when the anvil is in the closed position. The second staple forming distance differs from the first staple forming distance. A wedge sled is supported within the cartridge body for driving contact by the firing bar and actuating contact with the first and second pluralities of inside and outside staple drivers such that, as the firing bar moves within the elongated slot in a first axial direction, the wedge sled drives each of the inside and outside drivers toward the anvil to bring the staples supported thereon into forming contact with the anvil when the anvil is in the closed position.

In accordance with another embodiment of the present invention there is provided a staple cartridge for use with a surgical instrument that has an end effector that includes an anvil portion that is pivotally attached thereto for travel between open and closed positions and which further includes a firing bar that is selectively axially reciprocatable therein. One embodiment of the staple cartridge comprises a cartridge body that is sized to be supported within the end effector. The cartridge body has a longitudinally extending slot therein for reciprocatingly receiving the firing bar therein. A plurality of first inside staple drivers is axially aligned in a first row of first inside staple drivers on a first side of the longitudinally extending slot within the cartridge body. Each of the first inside staple drivers is movably supported within the cartridge body for selective movement towards the anvil when the anvil is in a closed position. Each of the first inside staple drivers supports at least one staple thereon. This embodiment further includes a plurality of first outside staple drivers that are axially aligned in a first row of first outside staple drivers that is adjacent to the first row of the first inside staple drivers. Each of the first outside staple drivers is movably supported within the cartridge body for selective driving movement toward the anvil when the anvil is in the closed position. Each of the first outside staple drivers supports another one of the staples thereon. The cartridge further comprises a wedge sled that is supported within the cartridge body for contact by the firing bar. The wedge sled comprises a first inside sled cam that has a first sled cam height. The first inside sled cam is oriented for sequential sliding actuating contact with the first inside staple drivers in the first row of first inside staple drivers when the firing bar is axially advanced through the elongated slot in a first axial direction such that the first inside staple drivers are driven toward the anvil a first distance equal to the first sled cam height. The wedge sled further comprises a first outside sled cam that has a second sled cam height that differs from the first sled cam height. The first outside sled cam is oriented for sequential actuating contact with the first outside staple drivers in the first row of the first outside staple drivers when the firing bar is axially advanced through the elongated slot in the first axial direction such that the first outside staple drivers are driven towards the anvil a second distance equal to the second sled cam height.

One feature of various embodiments of the present invention is to provide a staple cartridge for a stapling device that employs rows or other pluralities of identically sized staples while facilitating the ability of forming the staples with differing formed (final) heights. In some embodiments, the final heights may be varied across adjacent rows of staples. In other embodiments, the formed heights of the staples may be varied from staple to staple in a single row of staples. Accordingly, various embodiments of the invention provide solutions to the shortcomings of other staple cartridges and stapling devices that must employ different sizes of staples to achieve staples that have varying formed heights. Those of ordinary skill in the art will readily appreciate, however, that these and other details, features and advantages will become further apparent as the following detailed description proceeds.

BRIEF DESCRIPTION OF THE FIGURES

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and, together with the general description of the invention given above, and the detailed description of the embodiments given below, serve to explain the principles of the present invention.

FIG. **1** depicts a partially cut away side elevation view of a surgical stapling and severing instrument in an open position.

FIG. **2** depicts a cross-sectional side elevation detail view along the line **2-2** of FIG. **1** of an end effector of the surgical stapling and severing instrument.

FIG. **3** depicts an enlarged side elevation view of the firing bar of the surgical stapling and severing instrument of FIG. **2**.

FIG. **4** depicts an enlarged front view of the firing bar of the surgical stapling and severing instrument of FIG. **2**.

FIG. **5** depicts a cross-sectional side elevation detail view of an alternative end effector for the surgical stapling and

severing instrument of FIG. **1**, incorporating a firing bar that lacks a middle pin for preventing pinching of the end effector.

FIG. **6** depicts a side elevational view of a handle portion of a proximal end of the surgical stapling and severing instrument of FIG. **1** with a left side removed to expose interior parts in an unclamped, unfired ("start") position.

FIG. **7** depicts a perspective, exploded view of the handle portion of the proximal end of the surgical stapling and severing instrument of FIG. **1**.

FIG. **8** depicts a side elevational view of the handle portion of the proximal end of the surgical stapling and severing instrument of FIG. **1** with the left side removed to expose interior parts in the closed ("clamped") position.

FIG. **9** depicts a side elevational view of the handle portion of proximal end of surgical stapling and severing instrument of FIG. **1** with the left side removed to expose interior parts in the stapled and severed ("fired") position.

FIG. **10** depicts a plan view of a staple cartridge installed in an end effector of an embodiment of the present invention.

FIG. **11** is an enlarged plan view of a portion of a staple cartridge embodiment of the present invention.

FIG. **12** is a side view of a staple that may be employed with various embodiments of the present invention.

FIG. **13** is a front elevational view of one inside double driver of one embodiment of the present invention supporting two staples thereon.

FIG. **14** is a top view of the inside double driver and staples of FIG. **13**.

FIG. **14**A is an elevational view of the inside double driver of FIG. **13** within a portion of a staple cartridge mounted in the end effector and also illustrating a corresponding portion of the anvil when in a closed position.

FIG. **15** is a right side elevational view of the inside double driver and staples of FIGS. **13** and **14**.

FIG. **15**A is another side elevational view of the inside double driver of FIG. **15** wherein corresponding portions of the cartridge tray and anvil are illustrated in broken lines to depict the relationships therebetween.

FIG. **16** is a front elevational view of one outside single driver of one embodiment of the present invention supporting a staple thereon.

FIG. **16**A is another front view of the outside single driver of FIG. **16** with portions of the cartridge tray and anvil shown to illustrate the relationships therebetween.

FIG. **17** is a top view of the outside single driver and staple of FIG. **16**.

FIG. **18** is an isometric exploded view of the implement portion of the surgical stapling and severing instrument of FIG. **1**.

FIG. **19** is a section view taken along line **19-19** of FIG. **10** showing the cross-sectional relationship between the firing bar, elongate channel, wedge sled, staple drivers, staples and staple cartridge.

FIG. **19**A is another cross-sectional view of an end effector embodiment of the present invention showing the cross-sectional relationship between the firing bar, elongate channel, wedge sled, staple drivers, staples, staple cartridge and anvil.

FIG. **20** is a perspective view of one wedge sled embodiment of the present invention.

FIG. **21** is a side elevational view of an inside sled cam of the wedge sled depicted in FIG. **20**.

FIG. **22** is a side elevational view of an outside sled cam of the wedge sled depicted in FIG. **20**.

FIG. **23** is an isometric view of the end effector at the distal end of the surgical stapling and severing instrument of FIG. **1** with the anvil in the up or open position with the cartridge largely removed exposing a single staple driver and a double staple driver as exemplary and the wedge sled in its start position against a middle pin of the firing bar.

FIG. **24** is an isometric view of the end effector at the distal end of the surgical stapling and severing instrument of FIG. **1** with the anvil in the up or open position exposing the staple cartridge and cutting edge of the firing bar.

FIG. **25** is an isometric view of the distal end of the surgical stapling and severing instrument of FIG. **1** with the anvil in the up or open position with the staple cartridge completely removed and a portion of an elongate channel removed to expose a lowermost pin of the firing bar.

FIG. **26** is a side elevation view in section showing a mechanical relationship between the anvil, elongate channel, and staple cartridge in the closed position of the surgical stapling and severing instrument of FIG. **1**, the section generally taken along lines **26-26** of FIG. **24** to expose wedge sled, staple drivers and staples but also depicting the firing bar along the longitudinal centerline.

FIG. **27** is a cross-sectional view of a portion of one embodiment of a staple cartridge of the present invention wherein an outside cam of a wedge is adjacent to an outside single driver.

FIG. **28** is a cross-sectional view of a portion of one embodiment of a staple cartridge of the present invention wherein an outside cam of a wedge sled is engaging three outside single drivers.

FIG. **29** is a diagrammatic representation of lines of staples installed on each side of a cut line using a surgical stapling and severing instrument of one embodiment of the present invention.

FIG. **30** depicts a staple formed by one inside driver embodiment of the present invention.

FIG. **31** depicts another staple formed by one outside driver embodiment of the present invention.

FIG. **32** is a diagrammatic representation of lines of staples installed on each side of a cut line using a surgical stapling and severing instrument of another embodiment of the present invention.

FIG. **33** is a diagrammatic representation of lines of staples installed on each side of a cut line using a surgical stapling and severing instrument of another embodiment of the present invention.

FIG. **34** is a diagrammatic representation of lines of staples installed on each side of a cut line using a surgical stapling and severing instrument of another embodiment of the present invention.

FIG. **35** is a side elevation section view of the surgical stapling and severing instrument of FIG. **1** taken along the longitudinal centerline of the end effector in a partially closed but unclamped position gripping tissue.

FIG. **36** depicts a partially cut away side elevational view of the surgical stapling and severing instrument of FIG. **1** in the closed or clamped position.

FIG. **37** depicts a side elevation view of the surgical stapling and severing instrument of FIG. **1** in the closed or clamped position with tissue properly compressed.

FIG. **38** depicts a view in centerline section of the distal end of the surgical stapling and severing instrument of FIG. **1** in a partially fired position.

FIG. **39** depicts a partially cut away side elevation view of the surgical stapling and severing instrument of FIG. **1** in a partially fired position.

FIG. **40** depicts a view in centerline section of the distal end of the surgical stapling and severing instrument of FIG. **1** in a fully fired position.

FIG. **41** is a partially cut-away side elevational view of the surgical stapling and severing instrument of FIG. **1** in a full fired position.

DETAILED DESCRIPTION OF THE INVENTION

Turning to the Drawings, wherein like numerals denote like components throughout the several views, FIGS. **1** and **2** depict one embodiment of a surgical stapling and severing instrument **10** that is capable of practicing the unique benefits of the present invention. As the present Detailed Description proceeds, the reader will appreciate, however, that the unique and novel aspects of the present invention may be advantageously employed in connection with a variety of other staplers and stapler instruments without departing from the spirit and scope of the present invention. Accordingly, the scope of protection afforded to the various embodiments of the present invention should not be limited to use only with the specific type of surgical stapling and severing instruments described herein.

As can be seen in FIGS. **1** and **2**, the surgical stapling and severing instrument **10** incorporates an end effector **12** having an actuator or E-beam firing mechanism ("firing bar") **14** that advantageously controls the spacing of the end effector **12**. In particular, an elongate channel **16** and a pivotally translatable anvil **18** are maintained at a spacing that assures effective stapling and severing. The problems are avoided associated with varying amounts of tissue being captured in the end effector **12**.

It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a clinician gripping a handle of an instrument. Thus, the end effector **12** is distal with respect to the more proximal handle portion **20**. It will be further appreciated that for convenience and clarity, spatial terms such as "vertical" and "horizontal" are used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and absolute.

The surgical and stapling and severing instrument **10** includes a handle portion **20** that is connected to an implement portion **22**, the latter further comprising a shaft **23** distally terminating in the end effector **12**. The handle portion **20** includes a pistol grip **24** toward which a closure trigger **26** is pivotally drawn by the clinician to cause clamping, or closing, of the anvil **18** toward the elongate channel **16** of the end effector **12**. A firing trigger **28** is farther outboard of the closure trigger **26** and is pivotally drawn by the clinician to cause the stapling and severing of clamped tissue in the end effector **12**.

In practice, closure trigger **26** is actuated first. Once the clinician is satisfied with the positioning of the end effector **12**, the clinician may draw back the closure trigger **26** to its fully closed, locked position proximate to the pistol grip **24**. Then, the firing trigger **28** is actuated. The firing trigger **28** springedly returns when the clinician removes pressure. A release button **30** when depressed on the proximal end of the handle portion **20** releases any locked closure trigger **26**.

A closure sleeve **32** encloses a frame **34**, which in turn encloses a firing drive member **36** that is positioned by the firing trigger **28**. The frame **34** connects the handle portion **20** to the end effector **12**. With the closure sleeve **32** withdrawn proximally by the closure trigger **26** as depicted, the anvil **18** springedly opens, pivoting away from the elongate channel **16** and translating proximally with the closure sleeve **32**. The elongate channel **16** receives a staple cartridge **37**.

With particular reference to FIGS. **2-4**, the firing bar **14** includes three vertically spaced pins that control the spacing of the end effector **12** during firing. In particular, an upper pin **38** is staged to enter an anvil pocket **40** near the pivot between the anvil **18** and elongate channel **16**. When fired with the anvil **18** closed, the upper pin **38** advances distally within a longitudinal anvil slot **42** extending distally through anvil **18**. Any minor upward deflection in the anvil **18** is overcome by a downward force imparted by the upper pin **38**. Firing bar **14** also includes a lowermost pin, or firing bar cap, **44** that upwardly engages a channel slot **45** in the elongate channel **16**, thereby cooperating with the upper pin **38** to draw the anvil **18** and the elongate channel **16** slightly closer together in the event of excess tissue clamped therebetween.

The firing bar **14** advantageously includes a middle pin **46** that passes through a firing drive slot **47** formed in a lower surface of the cartridge **300** and an upward surface of the elongate channel **16**, thereby driving the staples therein as described below. The middle pin **46**, by sliding against the elongate channel **16**, advantageously resists any tendency for the end effector **12** to be pinched shut at its distal end. To illustrate an advantage of the middle pin **46**, FIG. **5** depicts an alternative end effector **12'** that lacks a middle pin on a firing bar **14'**. In this depiction, the end effector **12'** is allowed to pinch shut at its distal end, which tends to impair desired staple formation.

Returning to FIGS. **2-4**, a distally presented cutting edge **48** between the upper and middle pins **38**, **46** on the firing bar **14** traverses through a proximally presented, vertical slot **49** in the cartridge **37** to sever clamped tissue. The affirmative positioning of the firing bar **14** with regard to the elongate channel **16** and anvil **18** assure that an effective cut is performed.

The affirmative vertical spacing provided by the E-Beam firing bar **14** is suitable for the limited size available for endoscopic devices. Moreover, the E-Beam firing bar **14** enables fabrication of an anvil **15** with a camber imparting a vertical deflection at its distal end, similar to the position depicted in FIG. **5**. This cambered anvil **15** advantageously assists in achieving the desired gap in the end effector **12** even with an anvil **15** having a reduced thickness, which may be more suited to the size limitations of an endoscopic device.

With reference to FIGS. **6-9**, the handle portion **20** is comprised of first and second base sections **50** and **52**, which are molded from a polymeric material such as a glass-filled polycarbonate. The first base section **50** is provided with a plurality of cylindrically-shaped pins **54**. The second base section **52** includes a plurality of extending members **56**, each having a hexagonal-shaped opening **58**. The cylindrically-shaped pins **54** are received within the hexagonal-shaped openings **58** and are frictionally held therein for maintaining the first and second base sections **50** and **52** in assembly.

A rotating knob **60** has a bore **62** extending completely through it for engaging and rotating the implement portion **22** about its longitudinal axis. The rotating knob **60** includes an inwardly protruding boss **64** extending along at least a portion of the bore **62**. The protruding boss **64** is received within a longitudinal slot **66** formed at a proximal portion of the closure sleeve **32** such that rotation of the rotating knob **60** effects rotation of the closure sleeve **32**. It will be appreciated that the boss **64** further extends through frame **34** and into contact with a portion of the firing drive member **36** to effect their rotation as well. Thus, the end effector **12** (not shown in FIGS. **6-9**) rotates with the rotating knob **60**.

A proximal end **68** of the frame **34** passes proximally through the rotating knob **60** and is provided with a circumferential notch **70** that is engaged by opposing channel securement members **72** extending respectively from the base sections **50** and **52**. Only the channel securement member **72** of the second base section **52** is shown. The channel securement members **72**, extending from the base sections **50**, **52** serve to secure the frame **34** to the handle portion **20** such that the frame **34** does not move longitudinally relative to the handle portion **20**.

The closure trigger **26** has a handle section **74**, a gear segment section **76**, and an intermediate section **78**. A bore **80** extends through the intermediate section **78**. A cylindrical support member **82** extending from the second base section **52** passes through the bore **80** for pivotably mounting the closure trigger **26** on the handle portion **20**. A second cylindrical support member **83** extending from the second base section **52** passes through a bore **81** of firing trigger **28** for pivotally mounting on the handle portion **20**. A hexagonal opening **84** is provided in the cylindrical support member **83** for receiving a securement pin (not shown) extending from the first base section **50**.

A closure yoke **86** is housed within the handle portion **20** for reciprocating movement therein and serves to transfer motion from the closure trigger **26** to the closure sleeve **32**. Support members **88** extending from the second base section **52** and securement member **72**, which extends through a recess **89** in the yoke **86**, support the yoke **86** within the handle portion **20**.

A proximal end **90** of the closure sleeve **32** is provided with a flange **92** that is snap-fitted into a receiving recess **94** formed in a distal end **96** of the yoke **86**. A proximal end **98** of the yoke **86** has a gear rack **100** that is engaged by the gear segment section **76** of the closure trigger **26**. When the closure trigger **26** is moved toward the pistol grip **24** of the handle portion **20**, the yoke **86** and, hence, the closure sleeve **32** move distally, compressing a spring **102** that biases the yoke **86** proximally. Distal movement of the closure sleeve **32** effects pivotal translation movement of the anvil **18** distally and toward the elongate channel **16** of the end effector **12** and proximal movement effects closing, as discussed below.

The closure trigger **26** is forward biased to an open position by a front surface **130** interacting with an engaging surface **128** of the firing trigger **28**. Clamp first hook **104** that pivots top to rear in the handle portion **20** about a pin **106** restrains movement of the firing trigger **28** toward the pistol grip **24** until the closure trigger **26** is clamped to its closed position. Hook **104** restrains firing trigger **28** motion by engaging a lockout pin **107** in firing trigger **28**. The hook **104** is also in contact with the closure trigger **26**. In particular, a forward projection **108** of the hook **104** engages a member **110** on the intermediate section **78** of the closure trigger **26**, the member **100** being outward of the bore **80** toward the handle section **74**. Hook **104** is biased toward contact with member **110** of the closure trigger **26** and engagement with lockout pin **107** in firing trigger **28** by a release spring **112**. As the closure trigger **26** is depressed, the hook **104** is moved top to rear, compressing the release spring **112** that is captured between a rearward projection **114** on the hook **104** and a forward projection **116** on the release button **30**.

As the yoke **86** moves distally in response to proximal movement of the closure trigger **26**, an upper latch arm **118** of the release button **30** moves along an upper surface **120** on the yoke **86** until dropping into an upwardly presented recess **122** in a proximal, lower portion of the yoke **86**. The release spring **112** urges the release button **30** outward, which pivots the upper latch arm **118** downwardly into engagement with the upwardly presented recess **122**, thereby locking the closure trigger **26** in a tissue clamping position, such as depicted in FIG. **8**.

The latch arm **118** can be moved out of the recess **122** to release the anvil **18** by pushing the release button **30** inward. Specifically, the upper latch arm **118** pivots upward about pin **123** of the second base section **52**. The yoke **86** is then permitted to move proximally in response to return movement of the closure trigger **26**.

A firing trigger return spring **124** is located within the handle portion **20** with one end attached to pin **106** of the second base section **52** and the other end attached to a pin **126** on the firing trigger **28**. The firing return spring **124** applies a return force to the pin **126** for biasing the firing trigger **28** in a direction away from the pistol grip **24** of the handle portion **20**. The closure trigger **26** is also biased away from pistol grip **24** by engaging surface **128** of firing trigger **28** biasing front surface **130** of closure trigger **26**.

As the closure trigger **26** is moved toward the pistol grip **24**, its front surface **130** engages with the engaging surface **128** on the firing trigger **28** causing the firing trigger **28** to move to its "firing" position. When in its firing position, the firing trigger **28** is located at an angle of approximately 45° to the pistol grip **24**. After staple firing, the spring **124** causes the firing trigger **28** to return to its initial position. During the return movement of the firing trigger **28**, its engaging surface **128** pushes against the front surface **130** of the closure trigger **26** causing the closure trigger **26** to return to its initial position. A stop member **132** extends from the second base section **52** to prevent the closure trigger **26** from rotating beyond its initial position.

The surgical stapling and severing instrument **10** additionally includes a reciprocating section **134**, a multiplier **136** and a drive member **138**. The reciprocating section **134** comprises a wedge sled in the implement portion **22** (not shown in FIGS. **6-9**) and a metal drive rod **140**.

The drive member **138** includes first and second gear racks **141** and **142**. A first notch **144** is provided on the drive member **138** intermediate the first and second gear racks **141**, **142**. During return movement of the firing trigger **28**, a tooth **146** on the firing trigger **28** engages with the first notch **144** for returning the drive member **138** to its initial position after staple firing. A second notch **148** is located at a proximal end of the metal drive rod **140** for locking the metal drive rod **140** to the upper latch arm **118** of the release button **30** in its unfired position.

The multiplier **136** comprises first and second integral pinion gears **150** and **152**. The first integral pinion gear **150** is engaged with a first gear rack **154** provided on the metal drive rod **140**. The second integral pinion gear **152** is engaged with the first gear rack **141** on the drive member **138**. The first integral pinion gear **150** has a first diameter and the second integral pinion gear **152** has a second diameter which is smaller than the first diameter.

FIGS. **6**, **8** and **9** depict respectively the handle portion **20** in the start position (open and unfired), a clamped position (closed and unfired) and a fired position. The firing trigger **28** is provided with a gear segment section **156**. The gear segment section **156** engages with the second gear rack **142** on the drive member **138** such that motion of the firing trigger **28** causes the drive member **138** to move back and forth between a first drive position, shown in FIG. **8**, and a second drive position, shown in FIG. **9**. In order to prevent staple firing before tissue clamping has occurred, the upper latch arm **118** on the release button **39** is engaged with the second notch **148** on the drive member **138** such that the

metal drive rod **140** is locked in its proximal-most position, as depicted in FIG. **6**. When the upper latch arm **118** falls into the recess **122**, the upper latch arm **118** disengages with the second notch **148** to permit distal movement of the metal drive rod **140**, as depicted in FIG. **9**.

Because the first gear rack **141** on the drive member **138** and the gear rack **154** on the metal drive rod **140** are engaged with the multiplier **136**, movement of the firing trigger **28** causes the metal drive rod **140** to reciprocate between a first reciprocating position, shown in FIG. **8**, and a second reciprocating position, shown in FIG. **9**. Since the diameter of the first pinion gear **150** is greater than the diameter of the second pinion gear **152**, the multiplier **136** moves the reciprocating section **134** a greater distance than the drive member **138** is moved by the firing trigger **28**. The diameters of the first and second pinion gears **150** and **152** may be changed to permit the length of the stroke of the firing trigger **28** and the force required to move it to be varied. It will be appreciated that the handle portion **20** is illustrative and that other actuation mechanisms may be employed. For instance, the closing and firing motions may be generated by automated means.

One embodiment of an end effector **12** of the surgical stapling and severing instrument **10** is depicted in further detail in FIGS. **18**, **19**, and **23-26**. As described above, the handle portion **20** produces separate and distinct closing and firing motions that actuate the end effector **12**. The end effector **12** advantageously maintains the clinical flexibility of this separate and distinct closing and firing (i.e., stapling and severing). In addition, the end effector **12** introduces the aforementioned ability to affirmatively maintain the closed spacing during firing after the clinician positions and clamps the tissue. Both features procedurally and structurally enhance the ability of the surgical stapling and severing instrument **10** by ensuring adequate spacing for instances where an otherwise inadequate amount of tissue is clamped and to enhance the clamping in instances where an otherwise excessive amount of tissue has been clamped.

FIG. **10** depicts a staple cartridge embodiment **300** of the present invention installed in the end effector **12** with the firing bar **14** in its unfired, proximal position. The staple cartridge **300** has a cartridge body **302** that is divided by an elongated slot **310** that extends from a proximal end **304** of the cartridge **300** towards a tapered outer tip **306**. A plurality of staple-receiving channels **320***a*-**320***f* are formed within the staple cartridge body **302** and are arranged in six laterally spaced longitudinal rows **500**, **502**, **504**, **506**, **508**, **510**, with three rows on each side of the elongated slot **310**. Positioned within the staple-receiving channels **320***a*-**320***f* are the staples **222**. See FIGS. **10** and **11**.

The cartridge **300** further includes four laterally spaced longitudinal rows of staple drivers **330***a*, **330***b*, **370***a*, and **370***b* as shown in FIG. **11**. The "first" inside staple drivers **330***a* are slidably mounted within corresponding channels **320***b* and **320***c* such that each driver **330***a* supports two staples **222**, one in a channel **320***b* and one in a channel **320***c*. Likewise, the "second" inside drivers **330***b* are slidably mounted within channels **320***d* and **320***e* such that each driver **330***b* supports two staples **222**, one in a channel **320***d* and one in a channel **320***e*. The "outside" drivers **370***a* and **370***b* are slidably mounted within the staple-receiving channels **320***a* and **320***f*, respectively. Each of the outside drivers **370***a* and **370***b* supports a single staple **222**. Drivers **370***a* are referred to herein as "first" outside drivers and drivers **370***b* are referred to herein as "second" outside drivers.

FIG. **12** illustrates a staple **222** that may be used in connection with the various embodiments of the present invention. The staple **222** includes a main portion **223** and two prongs **225**. The prongs **225** each have a length "P" and the main portion has a width "W". The reader will appreciate that a variety of different types of staples may be employed. For example, for a vascular staple, "P" may be approximately 0.102 inches; for a regular staple, "P" may be approximately 0.134 inches; and for a thick tissue staple, "P" may be approximately 0.160 inches. For all such staples, "W" may be approximately 0.120 inches. Other sizes of staples **222** may be employed in the manners discussed below.

The inside staple drivers **330***a* located on one side of the elongated slot **310** are referred to herein as "first" inside staple drivers and the inside staple drivers **330***b* located on the other side of the elongated slot **310** are referred to herein as "second" inside staple drivers. As will be discussed in further detail below, in one embodiment, the second inside staple drivers **330***b* are identical to the first inside staple drivers **330***a*, except for their orientation in their respective channels in the cartridge body **302**.

FIGS. **13-15** illustrate one embodiment of a "first" inside double driver **330***a* for supporting and driving staples **222**. As can be seen in those Figures, the staple driver **330***a* has a primary driver portion **340** and a secondary driver portion **350** that is connected to the first primary portion **340** by a central base member **360**. The primary driver portion **340** has a primary driver base **342** that has a groove **343** therein adapted to mate with a corresponding vertically extending tongue (not shown) in the cartridge body **302** for guiding and stabilizing the driver **330***a* as it moves within its respective channel. The primary driver portion **340** further has a first forward support column **344** and a first rearward support column **346** protruding upward from the first driver base **342**. The first forward support column **344** has a first forward staple-receiving groove **345** therein and the first rearward support column **346** has a first rearwardly staple-receiving groove **347** therein. See FIGS. **13-15**. The first forward support column **344** and the first rearward support column **346** are spaced from each other and collectively form a first staple cradle **348** for supporting the main portion **223** of the staple **222** therein.

Similarly, the secondary driver portion **350** has a secondary driver base **352** and a secondary forward support column **354** and a secondary rearward support column **356** protruding out from the second driver base **352**. The secondary forward support column **354** has a secondary forward staple-receiving groove **355** therein and the secondary rearward support column **356** has a secondary rearward staple-receiving groove **357** therein. The secondary forward support column **354** and the secondary rearward support column **356** are spaced from each other and collectively form a secondary staple cradle **358** for supporting the main portion **223** of another staple **222** therein.

As can be seen in FIGS. **13** and **15**, the central base member **360** has an angled rearwardly facing edge **362** adapted to be engaged by a corresponding sled cam as will be discussed in further detail below. As can be seen in FIGS. **13** and **14**, in this embodiment, the secondary forward support column **354** of the secondary driver portion is oriented relative to the first rearward support column **346** such that the staple **222** that is supported in the secondary staple cradle **358** is longitudinally offset from the staple **222** in the first staple cradle **348**.

The reader will appreciate that the first inside drivers **330***a* are each installed in one orientation into a corresponding pair of channels **320***b* and **320***c* located on one side of the elongated slot **310** in the cartridge body **302**. The second

inside staple drivers **330***b* (located on the opposite side of the elongated slot **310** from the first inside staple drivers **330***a*) comprise inside drivers **330***a* rotated 180 degrees so that their respective angled surfaces **363** face towards the proximal end **304** of the cartridge **300** to enable them to be installed in pairs of corresponding channels **320***d* and **320***e*. Thus, in this embodiment, only one inside driver configuration is employed which thereby eliminates the need for two different inside staple driver configurations for channels on each side of the elongated slot **310**.

FIGS. **16** and **17** illustrate one embodiment of a "first" outside staple driver **370***a*. As can be seen in those Figures, a first outside staple driver **370***a* has a second base **372** that has an angled rearwardly facing portion **374**. Protruding upward from the second base **372** is a second forward support column **375** that has a second forward staple-receiving groove **376** therein. A second rearward support column **377** also protrudes upward from the second base **372** in a spaced-apart relationship with respect to the second forward support column **375**. The second rearward support column **377** has a second rearward staple-receiving groove **378** therein. The support columns **375**, **377** collectively form a second staple cradle **379** that is configured to support a staple **222** therein as illustrated in FIGS. **16** and **17**. The staple drivers **370***a* also have a laterally protruding rib **371** which is received in a corresponding groove (not shown) in the cartridge body **302** for guiding and stabilizing the driver **370***a* as it moves within its respective channel.

The reader will appreciate that a first outside driver **370***a* is installed in one orientation into a corresponding channel **320***a* on one side of the elongated slot **310**. A second outside staple driver **370***b* (to be located on the opposite side of the elongated slot **310** from the first outside staple drivers **370***a*) comprises an outside driver **370***a* rotated 180 degrees so that the angled surface **374'** thereon faces toward the proximal end **304** of the cartridge **300** to enable it to be installed in a corresponding channel **320***f* in the cartridge body **302**. Thus, in this embodiment, only one outside staple driver configuration is employed which avoids the need for two different outside staple driver configurations for channels on each side of the elongated slot **310**.

FIGS. **19** and **19**A illustrate in cross-section one embodiment of a staple cartridge of the present invention mounted within one type of end effector **12**. The end effector **12** in this embodiment employs a "stepped" anvil **18** of the type illustrated in FIGS. **23-25**. In other embodiments, however, the bottom surface of the anvil is planar and not stepped. Others can be seen in FIGS. **19**A, and **23-25**, the anvil **18** has a central portion **19** that is offset or not coplanar with the two lateral side portions **21**, **23**. Accordingly, in this embodiment, the upper surface **306** of the cartridge **300** is provided with a recessed central portion **307** and two lateral side portions **309** that are adapted to closely mate with the corresponding portions **19**, **21**, **23**, respectively, of the anvil **18**, when the anvil **18** is in the closed position. See FIG. **19**A.

As can be seen in FIG. **24**, in this embodiment, the under surfaces **200** of anvil **18** are provided with a series of forming pockets **202** that may be arranged in rows that correspond to the rows of channels in the cartridge **300**. That is, row **205** of pockets **202** may correspond to channel row **500**. Row **207** of pockets may correspond to channel row **502**. Row **209** of pockets **202** may correspond to channel row **504**. Row **211** of pockets **202** may correspond to channel row **506**. Row **213** of pockets **202** may correspond to channel row **508**. Row **215** of pockets **202** may correspond to channel row **510**. Each pocket **202** has at least one forming surface **203** therein that is adapted to contact the ends of the staple prongs **225** being driven therein to thereby cause the prongs **225** to bend inwardly toward each other. In one embodiment, each pocket **202** has two intersecting arcuate forming surfaces **203** that are oriented as shown in FIG. **14**A. Each arcuate forming surface has an apex **203'** that defines a maximum pocket depth "Z". However other forming pocket configurations could be employed.

Returning to FIGS. **18** and **19**, it can be seen that in one embodiment, the cartridge body **302** is mounted within the cartridge tray **224**. As illustrated in FIG. **19**, the cartridge body **302** is formed with two inside longitudinally extending slots **390** and two outside longitudinally extending slots **392**. Slots **390** and **392** extend from the proximal end **304** of the cartridge to its tapered outer tip **306** (shown in FIG. **10**). This embodiment further includes a wedge sled **400** that slidably supported on the cartridge tray **224**. One wedge sled embodiment **400** includes a pair of inside sled cams **410**, wherein one inside sled cam **410** corresponds to one of the inside longitudinally extending slots **390** and wherein the other inside sled cam **410** corresponds to the other inside longitudinally extending slot **390**. See FIG. **19**. The wedge sled **400** further includes a pair of outside sled cams **420**, wherein one outside sled cam **420** corresponds to one of the outside longitudinally extending slots **392** and the other outside sled cam **420** corresponds to the other outside longitudinally extending slot **392** as shown in FIG. **19**. When assembled, the cartridge tray **224** holds the wedge sled **400** and the drivers **330***a*, **330***b*, **370***a*, **370***b* inside the cartridge body **302**.

As can be seen in FIG. **18**, the elongate channel **16** has a proximally placed attachment cavity **226** that receives a channel anchoring member **228** on the distal end of the frame **34** for attaching the end effector **12** to the handle portion **20**. The elongate channel **16** also has an anvil cam slot **230** that pivotally receives an anvil pivot **232** of the anvil **18**. The closure sleeve **32** that encompasses the frame **34** includes a distally presented tab **234** that engages an anvil feature **236** proximate but distal to the anvil pivot **232** on the anvil **18** to thereby effect opening and closing of the anvil **18**. The firing drive member **36** is shown as being assembled from the firing bar **14** attached to a firing connector **238** by pins **240**, which in turn is rotatingly and proximally attached to the metal drive rod **140**. The firing bar **14** is guided at a distal end of the frame by a slotted guide **239** inserted therein.

FIGS. **20-23** illustrate one embodiment of the wedge sled **400** of the present invention. As can be seen in FIGS. **20** and **23**, the wedge sled **400** includes a central spacer portion **402** that extends between the inside sled cams **410**. A pusher block **404** is formed on the central spacer portion **402** for engagement with the middle pin **46** of the firing bar **14**. A side profile of one embodiment of an inside sled cam **410** is depicted in FIG. **21**. As can be seen in that Figure, the inside sled cam **410** has a bottom surface **412**, and a first camming surface **414** that forms an angle "G" with the bottom surface **412** and a second camming surface **415** that extends to a top surface **416**. In one embodiment, for example, the angle "G" may be 35 degrees and the angle "G'" may be 20 degrees. The height of the inside sled cam **410** (the distance between the bottom surface **412** and the top surface **416**) is represented as "first" sled cam height "H". In one embodiment, distance "H' is approximately 0.173 inches and the length of the top surface **416** may vary from embodiment to embodiment. As will be further evident as the present Detailed Description proceeds, the first sled cam height represents the

vertical distance that the inside sled cams **410** will drive the corresponding inside drivers **330***a*, **330***b* toward the anvil **18** during operation.

The wedge sled **400** further comprises lateral spacer portions **406** that extend between the inside sled cams **410** and the outside sled cams **420** as shown in FIGS. **20** and **23**. A side profile of one embodiment of an outside sled cam **420** is depicted in FIG. **22**. In this embodiment, the outside sled cam **420** has a bottom surface **422** and a first camming surface **424** that forms an angle "I" with respect to the bottom surface **422** and a second camming surface **425** that to a top surface **426**. In one embodiment, angle "I" may be approximately 35 degrees and angle "I'" may be approximately 20 degrees. The height of the outside sled cam **420** (the distance between the bottom surface **412** and the top surface **416**) is represented as the "second" sled cam height "J". In one embodiment, distance "J" is approximately 0.163 inches. The second sled cam height represents the vertical distance that the outside sled cams **420** will drive the corresponding outside drivers **370***a*, **370***b* toward the anvil **18** during operation. The reader will understand that the above-recited dimensions are illustrative of one embodiment and may vary for other embodiments.

With particular reference to FIG. **23**, a portion of the staple cartridge **300** is removed to expose portions of the elongate channel **16**, such as recesses **212**, **214** and to expose some components of the staple cartridge **300** in their unfired position. In particular, the cartridge body **302** (shown in FIG. **18**) has been removed. The wedge sled **400** is shown at its proximal, unfired position with a pusher block **404** contacting the middle pin **46** (not shown in FIG. **23**) of the firing bar **14**. The wedge sled **400** is in longitudinal sliding contact upon the cartridge tray **224** and includes wedges sled cams **410**, **420** that force upward the double drivers **330***a*, **330***b* and the single drivers **370***b*, **370***b* as the wedge sled **400** moves distally. Staples **222** (not shown in FIG. **23**) resting upon the drivers **330***a*, **330***b*, **370***a*, **370***b* are thus also forced upward into contact with the anvil forming pockets **202** in anvil **18** to form closed staples. Also depicted is the channel slot **45** in the elongate channel **16** that is aligned with the elongated slot **310** in the staple cartridge **300**.

FIG. **24** depicts the end effector **12**, which is in an open position by a retracted closure sleeve **32**, with a staple cartridge **300** installed in the elongate channel **16**. The firing bar **14** is at its proximal position, with the upper pin **38** aligned in a non-interfering fashion with the anvil pocket **40**. The anvil pocket **40** is shown as communicating with the longitudinal anvil slot **42** in the anvil **18**. The distally presented cutting edge **48** of the firing bar **14** is aligned with and proximally from removed from the vertical slot **49** in the staple cartridge **300**, thereby allowing removal of a spent cartridge and insertion of an unfired cartridge, which may be "snapfit" into the elongate channel **16**. Specifically, in this embodiment, extension features **316**, **318** of the staple cartridge **300** engage recesses **212**, **214**, respectively (shown in FIG. **23**) of the elongate channel **16**.

FIG. **25** depicts the end effector **12** of FIG. **23** with all of the staple cartridge **300** removed to show the middle pin **46** of the firing bar **14** as well as portion of the elongate channel **16** removed adjacent to the channel slot **45** to expose the firing bar cap **44**. In addition, portions of the shaft **23** are removed to expose a proximal portion of the firing bar **14**. Projecting downward from the anvil **18** near the pivot is a pair of opposing tissue stops **244** which serve to prevent tissue from being positioned too far up into the end effector **12** during clamping.

FIG. **26** depicts the end effector **12** in a closed position with the firing bar **14** in an unfired position. The upper pin **38** is in the anvil pocket **40** and is vertically aligned with the anvil slot **42** for distal longitudinal movement of the firing bar **14** during firing. The middle pin **46** is positioned to push the wedge sled **400** distally so that the sled cams **410**, **420** contact and lift double drivers **330***a*, **330***b* and the single drivers **370***a*, **370***b*, respectively, to drive them upwardly toward the anvil **18**.

As can be appreciated from reference to FIGS. **14**A, **15**A and **19**A, in one embodiment of the present invention, the distance between the bottom of the first staple-receiving grooves **345**, **347** forming the first staple cradle **349** and the apex **203'** of forming surfaces **203** of the corresponding forming pocket **202** of anvil **18**, when the anvil **18** is in the closed position and when the inside driver **330***a*, **330***b* is supported on the cartridge tray **224**, is referred to herein as the first staple forming distance "A". The distance between the bottom of the secondary staple-receiving grooves **345**, **347** forming the secondary staple cradle **349** and the apex **203'** of the forming surface **203** of the corresponding forming pocket **202** in the anvil **18** when the anvil **18** is in the closed position and the inside driver **330***a*, **330***b* is supported on the cartridge tray **224** is referred to herein as the secondary staple forming distance "B". In one embodiment, the first staple forming distance "A" and the secondary staple forming distance "B" are substantially equal to each other. In other embodiments, those distances "A" and "B" may differ from each other.

As illustrated in FIGS. **16**A and **19**A the distance between the bottom of the second staple-receiving grooves **376**, **378** that form the second staple cradle **379** and the apex **203'** of the forming surface **203** of a corresponding forming pocket **202** in anvil **18** when the anvil **18** is in the closed position and the outside drivers **370***a*, **370***b* are supported on the cartridge channel **224**, is referred to herein as a "second" staple forming distance "C".

FIGS. **27** and **28** illustrate the forming of staples supported on some of the first outside drivers **370***a*. In FIG. **27**, one of the outside sled cams **420** of the wedge sled **400** is initially contacting one of the outside drivers **370***a*. As the wedge sled **400** continues in the driving direction represented by arrow "K" in FIG. **28**, the outside sled cam **420** causes the outside drivers **370***a* drive the staples **222** supported thereby into the staple forming pockets **202** in the anvil **18**. Likewise, as the wedge sled **400** is driven in the driving direction "K", the inside sled cams **410** contact the inside drivers **330***a*, **330***b* and causes them to drive the staples **222** supported thereby into the corresponding staple forming pockets **202** in the anvil **18**.

As indicated above, in some applications involving an area of varied tissue composition, it can be desirable to form rows of staples wherein the formed (final) heights of the staples in a row that is the farthest distance away from the cut line are greater than the formed (final) heights of those staples in the row that is closest to the cut line. In other applications, it may be desirable for the formed heights of the staples in a single row to increase (or decrease) from staple to staple. Another clinical benefit would be to have the formed heights of the staples in the outermost rows larger than formed heights of the staples in the inside rows. The various embodiments of the subject invention can provide these results while employing identical staples in all of the rows.

As the present Detailed Description proceeds, those staples **222** in the outermost rows **520**, **530** of staples (those staples formed using the outside staple drivers **370***a*, **370***b*)

will be referred to hereinafter as staples **222'** and those staples in the innermost rows **522**, **524**, **526**, **528** of staples (those staples formed using the inside staple drivers **330***a*, **330***b*) will be referred to hereinafter as staples **222"**. It will be understood, however, that staples **222'** and **222"** are identical to each other prior to being formed by the various embodiments of the present invention. That is, staples **222'** and **222"** each have identical prong lengths "P" and widths "W".

Returning to FIGS. **14**A-**16**A and **21** and **22**, the above desired effects may be attained by altering the staple forming distances "A", "B", and "C" relative to each other and/or the sled cam heights "H" and "J". In one embodiment of the subject invention, for example, the height "H" of each of the inside sled cams **410** is substantially equal to the sled height "J" of each of the outside sled cams **420**. See FIGS. **21** and **22**. In this embodiment, the staple forming distances "A" and "B" are substantially equal to each other, but distances "A" and "B" are less than the staple forming distance "C". The distance "D" between the bottoms of the first staple-receiving grooves **345**, **347** and the bottom surface **342'** of the primary driver base **342** is substantially equal to the distance "E" between the bottoms of the secondary staple-receiving grooves **356**, **357** and the bottom surface **352'** of the secondary driver base portion **352**. See FIG. **15**. Also in this embodiment, the distance "F" between the bottoms of the second staple-receiving grooves **376** and **378** and the bottom surface **373** of the third base **372** of the outside drivers **370***a*, **370***b* (FIG. **16**) is less than distances "D" and "E" (FIG. **15**). Because the forming distance "C" is greater than the forming distances "A" and "B", the staples **222** supported and formed by the outside drivers **370***a*, **370***b* are not compressed as much as the staples supported and formed by the inside drivers **330***a*, **330***b*. It will be understood that similar results may be attained on the opposite side of the elongated slot **310** and the cut line **600** formed in the tissue by using the same arrangements and sizes of inside drivers **330***b* and outside drivers **370***b*. In an alternative embodiment, the same effect may be achieved by altering the depths of the forming pockets **202** corresponding to the drivers **330***a* and **370***b* such that forming distance "C" is greater than the forming distances "A" and "B". That is, the depth (distance "Z'" in FIG. **16**A) of the forming pockets **202** corresponding to the outside drivers **370***a*. **370***b* may be greater than the depth (distance "Z" in FIG. **14**A) of the forming pockets **202** that correspond to the inside drivers **330***a*, **330***b*.

FIG. **29** illustrates the rows of staples formed on each side of a cut line **600** utilizing this embodiment of the present invention wherein the forming distances "A" and "B" are equal to each other and the forming distance "C" is greater than the forming distances "A" and "B". For example, if forming distance "C" is 0.020" greater than forming distances "A" and "B", the formed height of the outside staples **222'** (represented as dimension "L" in FIG. **30**) in rows **520** and **530** would be 0.020 inches is greater than the formed height of the inside staples **222"** (represented as dimension "M" in FIG. **31**) in rows **522**, **524**, **526**, **528**.

The same result may be achieved by utilizing another embodiment of the present invention wherein the forming distances "A", "B" and "C" are essentially equal. In this embodiment, however, the height of each of the inside sled cams **410** (distance "H" in FIG. **21**) is greater than the height of each of the outside sled cams **420** (distance "J" in FIG. **22**). Thus, because the height "H" of the inside sled cams **410** is greater than the height "J'" of the outside sled cams **420**, the inside sled cams **410** will drive the corresponding inside drivers **330***a*, **330***b* further towards the anvil than the outside sled cams **420** will drive the corresponding outside drivers **370***a*, **370***b*. Such driving action will cause the staples supported by the inside drivers **330***a*, **330***b* to be compressed to a greater extent than those staples supported by the outside drivers **370***a*, **370***b*. For example, if distance "H" is 0.020 inches greater than distance "J", the formed height of staples **222'** in lines **520**, **530** would be 0.020" greater than the formed height of staples **222"** in lines **522**, **524**, **526**, **528**.

When employing yet another embodiment of the present invention, the outside rows **520**, **530** of staples **222'** and the inside rows **522**, **528** of staples **222"** may be formed with heights that are greater than the formed heights of the staples **222"** in the inside rows **524**, **526**. See FIG. **32**. This result is achieved by making the forming distances "C" greater than the forming distance "A" and making forming distance "A" greater than secondary forming distance "B".

Another embodiment of the present invention can be used to install staples where it is desirable for the formed heights of staples in a single row to vary. One such arrangement is depicted in FIG. **33**. As can be seen in FIG. **33**, the formed heights of the staples **222'** in the outside rows **520**, **530** increase when moving from the proximal ends **521**, **531** of each row **520**, **530**, respectively to the distal ends **523**, **533** of each row **520**, **530**, respectively. This effect may be accomplished by decreasing the forming distance "C" for each succeeding driver **370***a*, **370***b*. That is, the driver **370***a* closest the proximal end of the cartridge **300** would be sized to establish a forming distance "C" that is greater than the forming distance "C" achieved by the adjacent driver **370***a* and so on to achieve a condition wherein each succeeding staple **222'** (moving in the direction from the proximal end to the distal end of the cartridge **300**) would have larger formed heights. This result could also be attained in the staples **222"** in rows **522**, **524**, **526**, **528** by similarly altering the forming distances "A" and/or "B" attained by each driver **330***a*, **330***b*. Likewise, formed heights of the staples **222'** in the outside rows **520**, **530** could be made to decrease when moving from the proximal ends **521**, **531** of each row **520**, **530**, respectively, to the distal ends **523**, **533** of each row **520**, **530**, respectively. This result may be attained by increasing the forming distance of each succeeding driver **370***a*, **370***b*. That is, the driver **370***a* closest the proximal end of the cartridge **300** would have a forming distance "C" that is less than the forming distance "C" of the adjacent driver **370***a* and so on to achieve a condition wherein each succeeding staple **222'** (moving in the direction from the proximal end to the distal end of the cartridge) would have smaller formed heights. See FIG. **34**.

In use, the surgical stapling and severing instrument **10** is used as depicted in FIGS. **1-2** and **35-41**. In FIGS. **1-2**, the instrument **10** is in its start position, having had an unfired, fully loaded staple cartridge **300** snap-fitted into the distal end of the elongate channel **16**. Both triggers **26**, **28** are forward and the end effector **12** is open, such as would be typical after inserting the end effector **12** through a trocar or other opening into a body cavity. The instrument **10** is then manipulated by the clinician such that tissue **248** to be stapled and severed is positioned between the staple cartridge **300** and the anvil **18**, as depicted in FIG. **35**.

With reference to FIGS. **36** and **37**, the clinician then moves the closure trigger **26** proximally until positioned directly adjacent to the pistol grip **24**, locking the handle portion **20** into the closed and clamped position. The retracted firing bar **14** in the end effector **12** does not impede the selective opening and closing of the end effector **12**, but

rather resides within the anvil pocket **40**. With the anvil **18** closed and clamped, the E-beam firing bar **14** is aligned for firing through the end effector **12**. In particular, the upper pin **38** is aligned with the anvil slot **42** and the elongate channel **16** is affirmatively engaged about the channel slot **45** by the middle pin **46** and the firing bar cap **44**.

With reference to FIGS. **38** and **39**, after tissue clamping has occurred, the clinician moves the firing trigger **28** proximally causing the firing bar **14** to move distally into the end effector **12**. In particular, the middle pin **46** enters the staple cartridge **300** through the firing drive slot **47** to effect the firing of the staples **222** (not shown in FIGS. **38** and **39**) via wedge sled **400** toward the anvil **18**. The lowermost pin, or firing bar cap **44**, cooperates with the middle pin **46** to slidingly position cutting edge **48** of the firing bar **14** to sever tissue. The two pins **44**, **46** also position the upper pin **38** of the firing bar **14** within longitudinal anvil slot **42** of the anvil **18**, affirmatively maintaining the spacing between the anvil **18** and the elongate channel **16** throughout its distal firing movement.

With reference to FIGS. **40** and **41**, the clinician continues moving the firing trigger **28** until brought proximal to the closure trigger **26** and pistol grip **24**. Thereby, all of the ends of the staples **222** are bent over as a result of their engagement with the anvil **18**. The firing bar cap **44** is arrested against a firing bar stop **250** projecting toward the distal end of the channel slot **45**. The cutting edge **48** has traversed completely through the tissue. The process is complete by releasing the firing trigger **28** and by then depressing the release button **30** while simultaneously squeezing the closure trigger **26** to open the end effector **12**.

While the present invention has been illustrated by description of several embodiments and while the illustrative embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications may readily appear to those skilled in the art. The various embodiments of the present invention represent vast improvements over prior staple methods that require the use of different sizes of staples in a single cartridge to achieve staples that have differing formed (final) heights.

Accordingly, the present invention has been discussed in terms of endoscopic procedures and apparatus. However, use herein of terms such as "endoscopic" should not be construed to limit the present invention to a surgical stapling and severing instrument for use only in conjunction with an endoscopic tube (i.e., trocar). On the contrary, it is believed that the present invention may find use in any procedure where access is limited to a small incision, including but not limited to laparoscopic procedures, as well as open procedures. Moreover, the unique and novel aspects of the various staple cartridge embodiments of the present invention may find utility when used in connection with other forms of stapling apparatuses without departing from the spirit and scope of the present invention.

What is claimed is:

1. A surgical staple cartridge for use with a surgical stapling instrument that includes an anvil, wherein the anvil includes at least one tissue stop portion, and wherein the surgical staple cartridge comprises:

a cartridge body configured to be operably seated in a cartridge supporting portion of the surgical stapling instrument to confront a staple forming surface on the anvil when the surgical stapling instrument is moved to a closed position;

a plurality of first staple drivers movably supported within the cartridge body, each first staple driver defining a first staple support cradle for supporting a first surgical staple thereon;

a plurality of second staple drivers movably supported within the cartridge body, each second staple driver defining a second staple support cradle for supporting a second surgical staple thereon, wherein a proximal-most first driver and a proximal-most second driver are configured and positioned within the cartridge body such that at least a portion of one first surgical staple and at least a portion of one second surgical staple are located proximal to a distal end of the at least one tissue stop portion when the first and second surgical staples are driven into forming contact with the staple forming surface, wherein each first surgical staple comprises a first formed staple height, wherein each second surgical staple comprises a second formed staple height, wherein the first formed staple height and the second formed staple height are different; and

a longitudinal row of said plurality of first staple drivers and said plurality of second staple drivers.

2. The surgical staple cartridge of claim **1**, further comprising a plurality of surgical staples comprising said first surgical staples and said second surgical staples, wherein said plurality of surgical staples are removably positioned in said cartridge body in six rows of staples.

3. The surgical staple cartridge of claim **2**, wherein said cartridge body further comprising a proximal end and a distal end, wherein a longitudinal knife slot extends into said cartridge body toward said distal end from said proximal end, wherein said longitudinal row of said plurality of first staple drivers and said plurality of second staple drivers is positioned on a first side of said longitudinal knife slot, and wherein said surgical staple cartridge further comprises:

a second plurality of first staple drivers movably supported within the cartridge body;

a second plurality of second staple drivers movably supported within the cartridge body; and

a second longitudinal row of said second plurality of first staple drivers and said second plurality of second staple drivers, wherein said second longitudinal row of said second plurality of first staple drivers and said second plurality of second staple drivers is positioned on a second side of said longitudinal knife slot opposite to said first side.

4. The surgical staple cartridge of claim **3**, wherein said cartridge body comprises a stepped tissue-facing deck.

5. The surgical staple cartridge of claim **4**, wherein said six rows of staples comprises a first staple row and a second staple row, and wherein said stepped tissue-facing deck comprises:

a first portion comprising said first staple row;

a second portion comprising said second staple row; and

a longitudinal step between said first portion and said second portion.

6. The surgical staple cartridge of claim **2**, wherein said six rows of staples comprises at least one row of staples configured to assume varied formed heights along the length thereof.

7. The surgical staple cartridge of claim **2**, further comprising a plurality of driver base members, wherein each driver base member connects at least one said first staple driver and at least one said second staple driver.

8. A surgical staple cartridge for use with a surgical stapling instrument that includes an anvil, wherein the anvil

includes at least one tissue stop portion, and wherein the surgical staple cartridge comprises:

a cartridge body configured to be operably seated in a cartridge supporting portion of the surgical stapling instrument to confront a staple forming surface of the anvil when the surgical stapling instrument is moved to a closed position; and

a longitudinal row of staple drivers, comprising:

a plurality of first staple drivers movably supported within the cartridge body, each first staple driver defining a first staple support cradle for supporting a first surgical staple thereon; and

a plurality of second staple drivers movably supported within the cartridge body, each second staple driver defining a second staple support cradle for supporting a second surgical staple thereon, wherein the plurality of second staple drivers comprises a proximal-most second staple driver configured and positioned within the cartridge body such that at least a portion of the second surgical staple supported by the proximal-most second staple driver is located proximal to a distal end of the at least one tissue stop portion when the second surgical staple supported by the proximal-most second staple driver is driven into forming contact with the staple forming surface, wherein each first surgical staple comprises a first formed staple height, wherein each second surgical staple comprises a second formed staple height, and wherein the first formed staple height and the second formed staple height are different.

9. The surgical staple cartridge of claim **2**, wherein said six rows of staples comprises:

an inner staple row comprising said first surgical staples; and

an intermediate staple row comprising said second surgical staples.

10. The surgical staple cartridge of claim **9**, wherein said first surgical staples are configured to assume a first formed height, wherein said second surgical staples are configured to assume a second formed height, and wherein said second formed height is greater than said first formed height.

11. The surgical staple cartridge of claim **10**, wherein said first staple drivers comprise a first height, wherein said second staple drivers comprise a second height, and wherein said second height is greater than said first height.

12. The surgical staple cartridge of claim **8**, further comprising six rows of staples comprising a plurality of surgical staples removably positioned in said cartridge body, wherein said plurality of surgical staples comprising said first surgical staples and said second surgical staples.

13. The surgical staple cartridge of claim **12**, wherein said cartridge body further comprising a proximal end and a distal end, wherein a longitudinal knife slot extends into said cartridge body toward said distal end from said proximal end, wherein said longitudinal row of said staple drivers is positioned on a first side of said longitudinal knife slot, and wherein said surgical staple cartridge further comprises a second longitudinal row of staple drivers, comprising:

a second plurality of first staple drivers movably supported within the cartridge body; and

a second plurality of second staple drivers movably supported within the cartridge body, wherein said second longitudinal row of staple drivers is positioned on a second side of said longitudinal knife slot opposite said first side.

14. The surgical staple cartridge of claim **13**, wherein said six rows of staples comprises an inner row adjacent to said longitudinal knife slot, and wherein said first surgical staples are positioned in said inner row.

15. The surgical staple cartridge of claim **14**, wherein said six rows of staples comprises an intermediate row adjacent to said inner row, and wherein said second surgical staples are positioned in said intermediate row.

16. The surgical staple cartridge of claim **15**, wherein said first surgical staples are configured to assume a first formed height, wherein said second surgical staples are configured to assume a second formed height, and wherein said second formed height is greater than said first formed height.

17. The surgical staple cartridge of claim **16**, wherein said first staple drivers comprise a first height, wherein said second staple drivers comprise a second height, and wherein said second height is different than said first height.

18. The surgical staple cartridge of claim **12**, wherein said six rows of staples comprises a first row of staples and a second row of staples, and wherein said cartridge body comprises a deck, comprising:

a first portion comprising said first row of staples; and

a second portion comprising said second row of staples; and

a longitudinal step between the first portion and the second portion.

19. The surgical staple cartridge of claim **18**, further comprising a plurality of driver base members, wherein each driver base member connects at least one said first staple driver and at least one said second staple driver.

20. The surgical staple cartridge of claim **12**, wherein said six rows of staples comprises at least one row of staples configured to assume varied formed heights along the length thereof.

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